Completing the Bridge to the 90's

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A SECOND FIVE-YEAR PLAN FOR THE PROGRAMS
OF THE
NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL

COMPLETING THE BRIDGE TO THE 90's

June 1985

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sur demande)

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PREFACE

Intellectual Capital and Technological Change (1)

"Intellectual capital has become the most important asset by which an industrialized nation can maintain economic growth, enhance the quality of life of its citizens and strengthen its cultural heritage. The capacity of a nation to generate new ideas, to adapt to change, to innovate, to make the most effective use of its natural resources and to improve its productivity and international competitiveness are all critically dependent on an educated citizenry.

Particularly important is the quality of intellectual leadership that can be brought to bear on a nation's problems and effectively used to identify and exploit new opportunities. This is especially true in research and development, activities which have assumed a new sense of urgency with the recognition by all sectors of society that our Country's capacity to compete in this high-technology age is intimately dependent on our ability to innovate, to adapt to change and, indeed, to initiate it.

The time has passed when we can place almost total reliance on technologies imported from other countries. In many areas of industrial activity, the time span between discovery and application has become too short and the degree of international competitiveness too great to make this an economically viable option. We, of course, shall continue to draw heavily on foreign technology, but even our choices of the technology to import must be made on the basis of sound scientific and engineering knowledge. This requires a strong cadre of professionals, many of whom are themselves working at the frontiers of that knowledge.

Today, Canadians do not even have the option of being simply "hewers of wood and drawers of water" without making a sustained investment in R and D, because of the impact of new technologies on the competitiveness of our resource industries and on efforts to maintain a quality environment. Without increased technological competence, Canada will lose its remaining competitive edge in even the resource-based export market.

Therefore, as a nation, we must give first priority to the enhancement of our intellectual resources by improving the quality of education at all levels, by increasing our investment in new ideas and by encouraging innovation in every sector of our society. The risks sometimes will be high, but we have no other choice if we wish to develop the future leaders of our industries, universities and government and to sustain and improve the quality of life for our people."

---

(1) An extract from the NSERC Brief to the Royal Commission on the Economic Union and Development Prospects for Canada, October 1983 - pages 3 & 4.

HIGHLIGHTS

1. Canada's agenda for economic renewal based upon "R&D, Innovation and Technology Diffusion" will be greatly impeded by critical shortages of skilled researchers trained at the Masters and PhD levels and by the lack of an adequate knowledge base in the natural sciences and engineering in our universities.

2. Those same deficiencies will prevent the aspired-for doubling of Canada's R&D effort to 2.5% of GNP by 1990. In fact, given a reasonable growth of GNP, Canada will have difficulty in attaining an R&D investment of 1.5% of GNP by 1990, a target initially set for 1983.

3. Movement towards the national targets, and towards a more secure future based upon technological advancement, will depend upon immediate and sustained action designed to:

   a) expand the universities' knowledge-producing and research training capacity

   b) attract more young Canadians into the graduate schools of Canada

   c) equip the university laboratories with state-of-the-art facilities and a much improved level of research infrastructure

   d) fund our existing research faculty at levels which more closely reflect the high cost of frontier science

   e) forge closer links between the university and industrial research communities, and

   f) provide the critical mass and concentration of effort so essential for a competitive position in many of the rapidly expanding areas of research and technology.

   Without such action we will continue to fall behind the efforts of competing nations and will be inviting our most talented researchers to seek out more stimulating opportunities elsewhere.

4. NSERC's first Five-Year Plan and the resultant investment of $1.2 billion has already started the recovery process. While the overall budget did not meet expectations, and the staccato nature of the funding decisions was hardly conducive to good planning, there has been an effective level of recovery from the previous "decade of decline". There is a general atmosphere of rejuvenation; equipment is more sophisticated and in a much better state of repair; the graduate schools have a much larger complement of Canadian students; and, the truly productive researchers are receiving grants which, while still very modest by international standards, represent real increases over previous levels. Finally, there is encouraging and widespread improvement in the level of cooperation and understanding between the industrial and university communities; a growing recognition that, in this increasingly technological world, their futures are inextricably entwined.

5. However, the needs have run ahead of the progress achieved and increased levels of investment are required. While university-based research is the best possible R&D investment, producing both research and new research talent, it is also one of the major casualties of the current squeeze on university budgets. A new federal-provincial agreement for the support of post-secondary education is urgently required, one which specifically meets the needs of the research community.

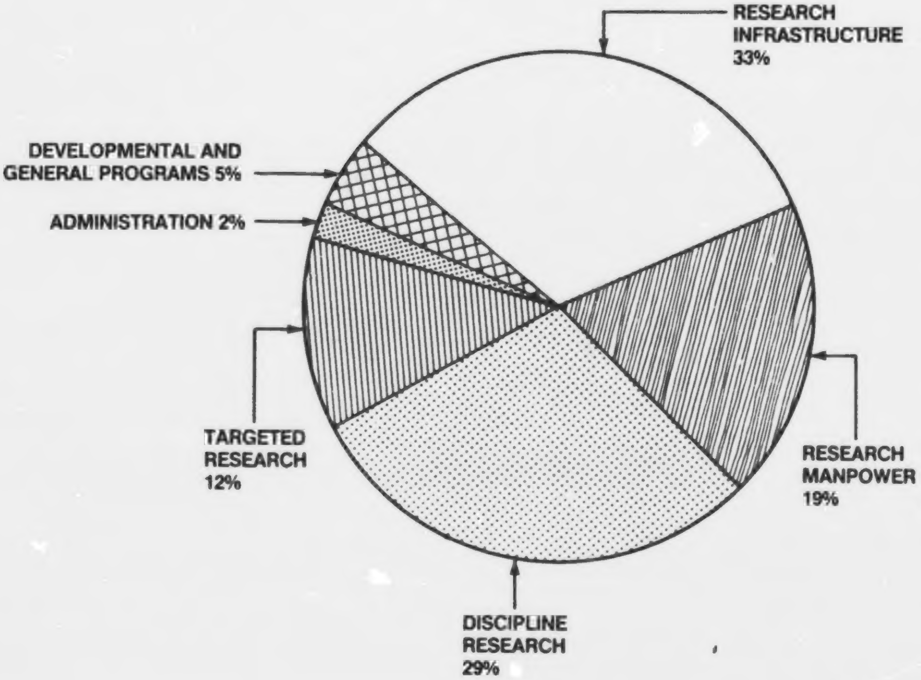
6. NSERC's second Five-Year Plan calls for funding levels which match the pronouncements and expectations of governments and industry alike regarding our overall R&D efforts. The annual budget of the Council would grow from $311.6 million in 1984-85 to $702.9 million in 1989-90 (expressed in constant 1984-85 dollars); a real growth of 18% a year. Over the five-year period the cumulative real funding increment would be $1.2 billion (constant 1984-85 dollars). The allocation of that increase, as shown in Figure A, reflects the critical need for improved research infrastructure (equipment plus services) and expanded research training through Research Manpower and Discipline Research programs.

7. The second Five-Year Plan, however, was developed upon an assumed funding base of $316.2 million. That level was not obtained by NSERC in 1984-85; furthermore, the budget that was achieved for that year, $311.6 million, does not carry forward into future years. Accordingly, even before this second Five-Year Plan can be launched the funding base has to be stabilized, i.e., the first Plan must be completed. The cumulative five-year investment required to do that is $171.6 million (constant 1984-85 dollars).

8. The total five-year funding approval sought is therefore $1.4 billion (constant 1984-85 dollars). The breakdown of proposed budgets by activity area is given in Table 1. The two-component nature of the need is highlighted by Table 2. The size of the research community directly benefitting in some way would approach 30,000 by 1990.

Figure A

Share of Cumulative Real Growth Proposed in the Second Five-Year Plan, 1985-86 to 1989-90



9. If economic renewal is, in fact, to be built upon "R&D, Innovation and Technology Diffusion", then an up-front investment of this magnitude in new talent and new knowledge is an essential prerequisite. The challenge has to be addressed with the same priority and commitment as has been given to energy self sufficiency. Yet the incremental **five-year** funding sought by this Plan to sustain our research capacity in an increasingly demanding technological world, is less than that spent on frontier drilling incentives in **any one** of the past five years.

10. NSERC contends that that is the context within which this Plan should be assessed; are we really prepared as a nation to decrease our overwhelming dependence on depleting physical resources and to turn our attention increasingly towards a world where we must survive largely on the basis of our intellectual capacity? That will be the test of this Plan, and that will also be a critical test of this nation and its resolve to start that change of emphasis. This Plan is very much part of the process of laying down the foundation and preparing the way; it is very much "The Bridge to the '90s".

Table 1

The Recommended Plan of Action
(millions of constant 1984-85 dollars)

Activity	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Research Manpower	51.4	71.0	89.1	99.2	110.7	120.4
Research Infrastruture	33.1	75.4	111.3	123.0	136.1	150.3
Discipline Research	142.8	162.8	185.2	210.6	239.2	271.5
Targeted Research	46.4	57.9	67.8	76.5	85.7	91.9
Development and General Programs	26.9	30.4	34.7	38.7	43.1	47.7
Total Program Investment	300.6	397.5	488.1	548.0	614.8	681.8
Administration (P-Y)	11.0 (138)	12.3 (165)	15.1 (200)	16.9 (225)	19.0 (250)	21.1 (275)
Total Investment	311.6	409.8	503.2	564.9	633.8	702.9

Table 2

Required Investment for the Recommended Plan of Action
(millions of **constant** 1984-85 dollars)

		Second Five-Year Plan					Total additional investment required
		(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90	
(a) Approved Budgets		287.1	280.8	280.5	280.5	280.5	
(b) "Catch up" adjustment		29.1	35.4	35.7	35.7	35.7	171.6
(c) Base budget used for Plan		316.2	316.2	316.2	316.2	316.2	
(d) Increments required		93.6	187.0	248.7	317.6	386.7	1,233.6
(e) Total budget proposed in Plan		409.8	503.2	564.9	633.8	702.9	
- Total increase required [(b) + (d)]		122.7	222.4	284.4	353.3	422.4	1,405.2
- Annual A-Base increments:	Year 1	122.7-------	----------	----------	----------	----------	
	Year 2		99.7-------	----------	----------	----------	
	Year 3			62.0-------	----------	----------	
	Year 4				68.9-------	----------	
	Year 5					69.1	

SUMMARY

1. This document presents the second Five-Year Plan of the Natural Sciences and Engineering Research Council, a plan for the support of university-based research and research training during the period 1985-86 to 1989-90. It does this through the following sequence of analysis:

   Section I: "The Last Five Years" - An analysis of the results of the first Five-Year Plan and a "report card" on expenditures of $1.2 billion.

   Section II: "A Reassessment" - A look at the new targets and new challenges facing the national R&D effort and the programs of NSERC.

   Section III: "Completing the Bridge to the '90s: NSERC's Second Five-Year Plan" - A program by program analysis of what NSERC can do to help meet national R&D aspirations and the resultant investment requirements.

Section I: "The Last Five Years"

2. While the investment levels proposed by NSERC's first Five-Year Plan were not realized, the budget increases were substantial (Figure A). A major problem, however, was the short-term nature of some of the increases and the funding uncertainty which resulted; in three of the five years the additional funds were approved within two months of the end of the fiscal year. (Chapter 1, pages 3 to 11.)

3. The incremental funding has been applied in a manner totally consistent with the objectives of the first Plan (Figure B), with the greatest emphasis placed on the training of research manpower and on research infrastructure. (Chapter 1, pages 3 to 11.)

4. The first Five-Year Plan identified a shortage of trained researchers at the MSc and PhD levels as a major impediment to attaining the R&D investment target of 1.5% of Gross National Product by 1983. The initiatives taken by the Council have breathed new life into the graduate schools of Canada; in 1984-85, over 2,500 undergraduates were awarded NSERC research awards to work on R&D projects in a university or industry research environment; applications for NSERC postgraduate scholarships have increased by 70% since 1979; the number of scholarships held has almost doubled; and graduate school enrolment by Canadian citizens and permanent residents has risen from 8567 to 11987 in the five-year period. NSERC is also supporting about 600 of Canada's brightest young PhDs in university and industrial research positions. In spite of this improvement, Canada remains import-dependent for research talent. (Chapter 2, pages 13 to 27.)

Figure A

Proposed and Actual Funding Levels of the First Five-Year Plan Total Budget

(millions of constant 1984-85 dollars)

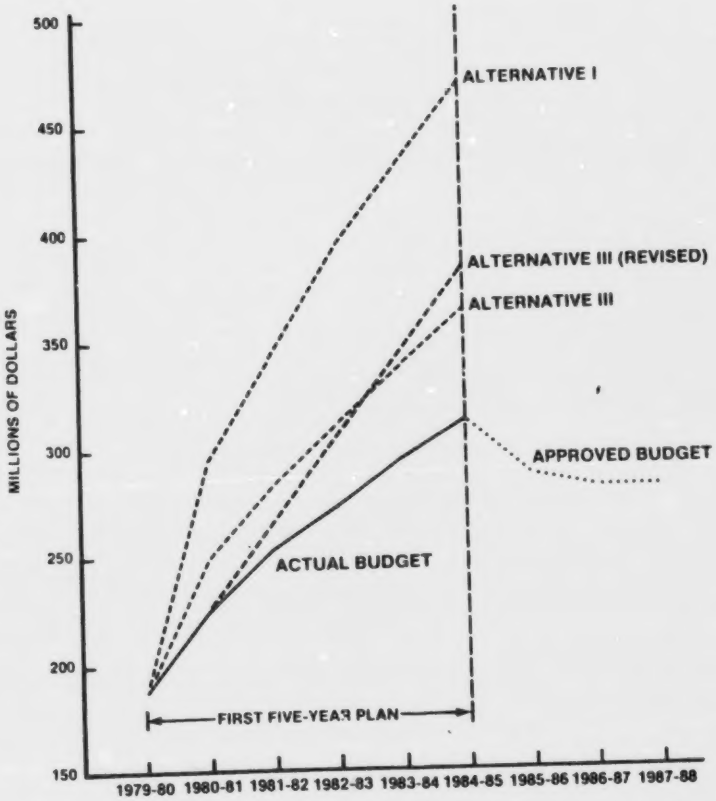
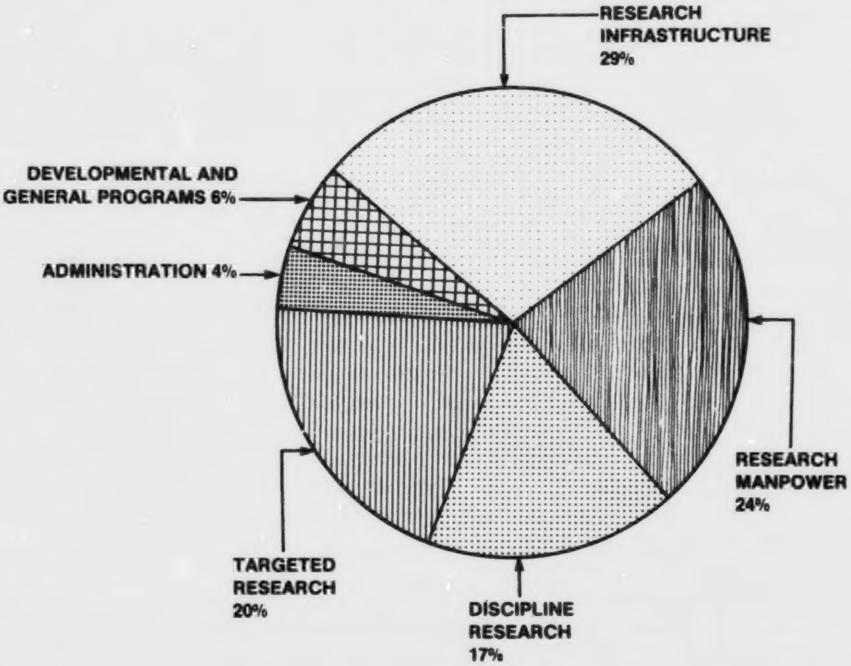


Figure B

Share of Cumulative Real Growth in the First Five-Year Plan



5. The greatest casualty of the underfunding during the '70s was research equipment. The serious obsolescence that was allowed to develop is still with us, but major improvements have been made. NSERC has played the largest single role in this recovery through an increased investment of $ 110 million (constant 1984-85 dollars); this represents 26% of the new funding made available to the Council over the five-year period (26% out of the 29% shown as "Research Infrastructure" in Figure B). However, capital equipment needs a sound base of infrastructure support to be truly effective. NSERC's efforts in that regard have been quite modest because of budget limitations. The problem, however, is becoming increasingly severe because of pressures on the operating funds of the universities. (Chapter 3, pages 29 to 39.)

6. The foundation upon which NSERC's total effort depends is the program of free enquiry supported largely through Operating Grants. Over 6,000 university professors use these grants to pursue research ranging from very fundamental to very applied. These grants provide the continuity of support that is essential if professors are to effectively pursue shorter-term targeted or contractual research endeavours. The increased funding allocated to Operating Grants over the past five years, $ 52 million (constant 1984-85 dollars), was fully used in the support of first-time applicants. Increased funding to the established research force had to come through greater selectivity of awards. Council has successfully pushed for greater selectivity and has also improved the overall process of peer review, but the purchasing power of the average grant is still 14% less than that of 1969-70. (Chapter 4, pages 41 to 55.)

7. NSERC has succeeded in bringing the university research community and the industrial community much closer together. The major vehicles have been the program of Strategic Grants and the new program of University-Industry Awards. The early resistance to Strategic Grants, where socio-economic relevance must be established, has almost totally dissipated. In the 1984-85 competition, 250 new awards were made involving $14 million and the major difficulty facing the program was a lack of funding to meet the needs of all highly-recommended research projects. The more recent University-Industry program has exceeded all expectations of success, with Canadian industry showing a desire to join with NSERC to invest in university-based research and to fund Research Professorships. (Chapter 5, pages 57 to 74.)

8. The Engineering research community, which had felt its particular needs were being lost in a heavily "science-oriented" program has fared very well under the first Five-Year Plan. The number of engineers in graduate schools has more than doubled; new indicators to measure the research productivity of engineers applying for grants have been developed and implemented; and engineers have been one of the major beneficiaries of new or expanded programs such as University-Industry, Strategic and Research Equipment Grants and the National Microelectronics Facility. (Chapter 6, pages 75 to 84.)

9. Although nearly all of NSERC's awards are based on the excellence of the applicant and the application, the regional distribution of funds is very good (Table 28 and 29, pages 86 and 87.) Where particular deficiencies of participation or success are noted, remedial programs are being pursued; these "research development" efforts are now the focus of a major program review. (Chapter 7, pages 85 to 97.)

10. NSERC's administration costs continue to be about 3% of total budget. However, severe pressures have been building on the staff, due largely to the labour-intensive nature of the more targeted research programs, the push for greater selectivity on grants, and greater interaction with provincial and other agencies. (Chapter 9, pages 107 to 112.)

11. In summary, with the funding increases received, the Council has been able to follow closely the priorities identified by the first Five-Year Plan and endorsed by successive governments. However, the process of recovery is by no means complete, and the uncertainty which has prevailed regarding funding for the last year of the first Plan cannot help but raise questions within the research community regarding a long-term commitment to a greater national R&D effort. This hesitation is particularly apparent and worrisome to the young graduates who are seeking clear signals from the government as they approach critical career path decisions; they in turn, represent a resource this nation urgently requires in the race for new technologies.

Section II: "A Reassessment"

12. Announced R&D investment targets continue to try to move Canada closer to the international competition. The "doubling" scenarios envisaged, however, involve major new investments and a dramatic need for more research talent. Canadian universities are ill-equipped to meet the pressures for more R&D activity and for the training of future research leaders. Funding for those universities has had a real growth of only 8.5% since 1970 while undergraduate enrolments and R&D funding pressures have increased by over 50%. The current federal-provincial arrangements for the support of university research are sadly failing this nation at a time when such research, and the associated research training, have become critically important for our economic future. (Chapter 11, page 117 to 126.)

13. NSERC has analysed the nation's R&D targets in terms of the research talent required. This analysis concludes that any attempt to increase R&D expenditure from its current level of 1.24% of GNP will be severely constrained by a shortage of research talent. The shortages will be particularly critical at the PhD level. An assessment of the import option suggests we can no longer be so heavily dependent upon imported talent; in short, Canada must become far more self-sufficient with regard to our intellectual resources. Immediate action is required throughout our educational system as the problem will intensify in the 1990s. (Chapter 12, pages 127 to 141.)

14. In summary, the research environment upon which NSERC must launch its next Five-Year Plan is much improved over that of 1979. There are, however, significant weaknesses or opportunities that must be met during the rest of this decade. They relate mainly to Operating Grant levels that are only a fraction of what they should be; to equipment renewal and the associated network of infrastructure support; to the increasing need to develop critical masses of research talent in specific areas and to the forging of stronger university-industry links. (Chapter 13, pages 143 to 152.)

Section III: "Completing the Bridge to the 90s: NSERC's Second Five-Year Plan"

15. While the national R&D targets cannot be achieved by 1990, the goals themselves are reasonable and should be pursued. Investment in our universities and in university research is an essential starting point. A new federal-provincial agreement on the funding of post-secondary education and research is essential as is approval of NSERC's **second** Five-Year Plan. However, funding for the **first** Plan must first be completed. To do that, $29 million (constant 1984-85 dollars) is required in 1985-86 and a total of $172 million over the next five-year period. If that firming of the foundation is not realized, some of the gains of the past five years will be lost and the whole thrust of the Council's activities will be diminished. (Chapter 14, pages 153 to 156.)

16. The projected, but inadequate supply of research talent assumes a major increase in NSERC investment in specific research training initiatives. Expenditures are projected to grow from $51 million in 1984-85 to $82 million in 1989-90 (in constant 1984-85 dollars). The program expansion is "supply limited" as the Council can only work with the supply of students already in the system. By 1990 almost 10,000 undergraduate, postgraduate and postdoctoral scholars will have their research training directly supported by NSERC. Many others will survive on stipends paid to them by professors from their NSERC research grants. By 1990, it is estimated that some 30,000 individuals will be benefitting from NSERC's total program activity. (Chapter 15, pages 157 to 164.)

17. While considerable progress has been achieved towards correcting the obsolescence of university research equipment, it remains as a major problem. In addition, and of growing concern, is the lack of essential infrastructure to support both the research equipment and the research effort itself. A special NSERC Task Force has identified the need for an immediate injection of $48 million to correct just part of this problem; a problem being greatly aggravated by the forced withdrawal of such services by the universities themselves. The largest single component of new spending called for by the Plan would go into these combined activities of equipment and infrastructure. By 1990 the proposed annual investment would be about $150 million (in constant 1984-85 dollars). (Chapter 16, pages 165 to 167.)

18. During the next five years special attention must be given to the level of the Operating Grants awarded by NSERC. In spite of higher than average inflation pressures, more expensive research challenges, and charges for services that used to be provided by the universities themselves, the average Individual Operating Grant of $21,857 is still 14% less in spending power than that of 1969-70. That level of subsistence funding hardly provides the stimulating research environment needed to move towards the governmnent's R&D targets. NSERC's proposal calls for a reasonable funding response to new applicants to the system over the next five years, coupled with the average grant to established researchers growing to $35,600 (constant 1984-85 dollars) by 1989-90. That level of funding would still be only one half of that required for a truly effective program by a competent researcher. NSERC's overall investment in the Discipline Research program (consisting mainly of Operating Grants) would grow from $143 million in 1984-85 to $272 million by 1989-90 (constant 1984-85 dollars). (Chapter 17, pages 169 to 173.)

19. The Council proposes to continue the expansion of both its Strategic Grants and University-Industry programs; programs that have successfully introduced more relevant and applied research into university laboratories and have brought the university researcher and the user community closer together. An orderly expansion of Strategic Grants, with funding rates recovering to 35% over the five-year period, would double that particular investment to almost $65 million (constant 1984-85 dollars) by 1989-90. While there has been just over one year's experience with the University-Industry program, the growth of applications would support a budget increase from $11 million in 1984-85 to $24 million in 1989-90 (constant 1984-85 dollars). Added funding is also required for the existing national VLSI design network operated by the Canadian Microelectronics Corporation. (Chapter 18, pages 175 to 180.)

20. The fine tuning of NSERC's programs is provided by a number of relatively modest programs that also require real growth. Among these are the General Research Grants to University Presidents and the Research Development Grants designed to provide special assistance to francophone and small universities. In addition, NSERC is receiving an increasing number of proposals in support of major activities of a collaborative or multidisciplinary nature. Such requests for funds are frequently unexpected and unscheduled, but require a fast response so as not to miss unique opportunities. Accordingly, it is proposed that the budget of the program of Collaborative Special Projects be provided with a special increase equal to 2% of NSERC's total program budget. Overall, the increases proposed for Council's complementary programs bring the associated investment from about $27 million in 1984-85 to $48 million in 1989-90 (in constant 1984-85 dollars). (Chapter 19, pages 181 to 188.)

21. On the assumption that the proposed mix of programs is maintained, NSERC believes it can hold its administrative costs to 3% of total budget over the five-year period. Those costs would total about $21 million in 1989-90 (in constant 1984-85 dollars), which include the salary costs of 275 person-years. (Chapter 20, pages 189 to 193.)

22. NSERC's second Five-Year Plan has been built up through detailed analyses of a number of interdependent programs. The end result is viewed as a prerequisite for any sustained national effort in research and development, which, in turn, has been identified as one of the pillars of economic renewal. On top of the $172 million required over five years to stabilize the funding of the first Five-Year Plan, a further cumulative **incremental** investment of $1.2 billion (in constant 1984-85 dollars) is called for by the second Five-Year Plan. Over that period the annual budgets of NSERC would grow from the assumed base of $316 million to $703 million (all in constant 1984-85 dollars). The document presents an option that would delete two programs, that, while very essential, would move the Council further into funding areas previously met largely by provincial grants. Council cannot recommend the dropping of these urgent proposals, but the end effect would be to reduce the cumulative five-year incremental budget to $1.0 billion and the 1989-90 budget to $600 million (all in constant 1984-85 dollars). (Chapter 21, pages 195 to 205.)

23. The levels of funding called for in the "Recommended Plan of Action" and the proposed allocation of that investment are shown in Tables 1 and 2 and Figures C and D below.

Table 1

The Recommended Plan of Action
(millions of constant 1984-85 dollars)

Activity	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Research Manpower	51.4	71.0	89.1	99.2	110.7	120.4
Research Infrastructure	33.1	75.4	111.3	123.0	136.1	150.3
Discipline Research	142.8	162.8	185.2	210.6	239.2	271.5
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Development and General Programs	26.9	30.4	34.7	38.7	43.1	47.7
Total Program Investment	300.6	397.5	488.1	548.0	614.8	681.8
Administration (P-Y)	11.0 (138)	12.3 (165)	15.1 (200)	16.9 (225)	19.0 (250)	21.1 (275)
Total Investment	311.6	409.8	503.2	564.9	633.8	702.9

Figure C

Share of Cumulative Real Growth in the Second Five-Year Plan
1985-86 to 1989-90

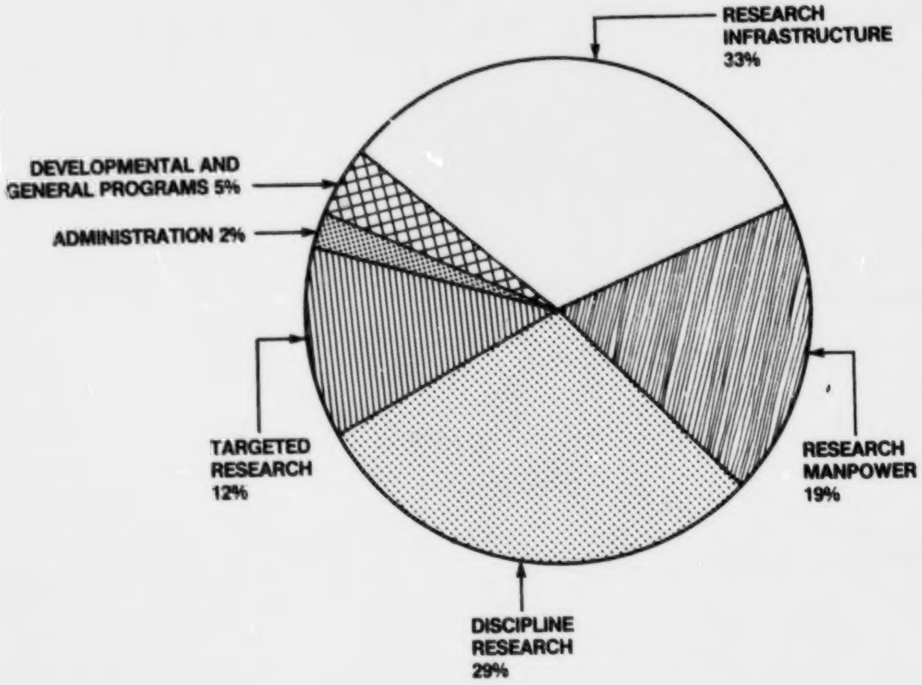

Table 2

Required Investment for the Recommended Plan of Action

(millions of **constant** 1984-85 dollars)

		Second Five-Year Plan				
		(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90	Total additional investment required
(a) Approved Budgets		287.1	280.8	280.5	280.5	280.5	
(b) "Catch up" adjustment		29.1	35.4	35.7	35.7	35.7	
(c) Base budget used for Plan		316.2	316.2	316.2	316.2	316.2	
(d) Increments required		93.6	187.0	248.7	317.6	386.7	171.6
(e) Total budget proposed in Plan		409.8	503.2	564.9	633.8	702.9	1,233.6
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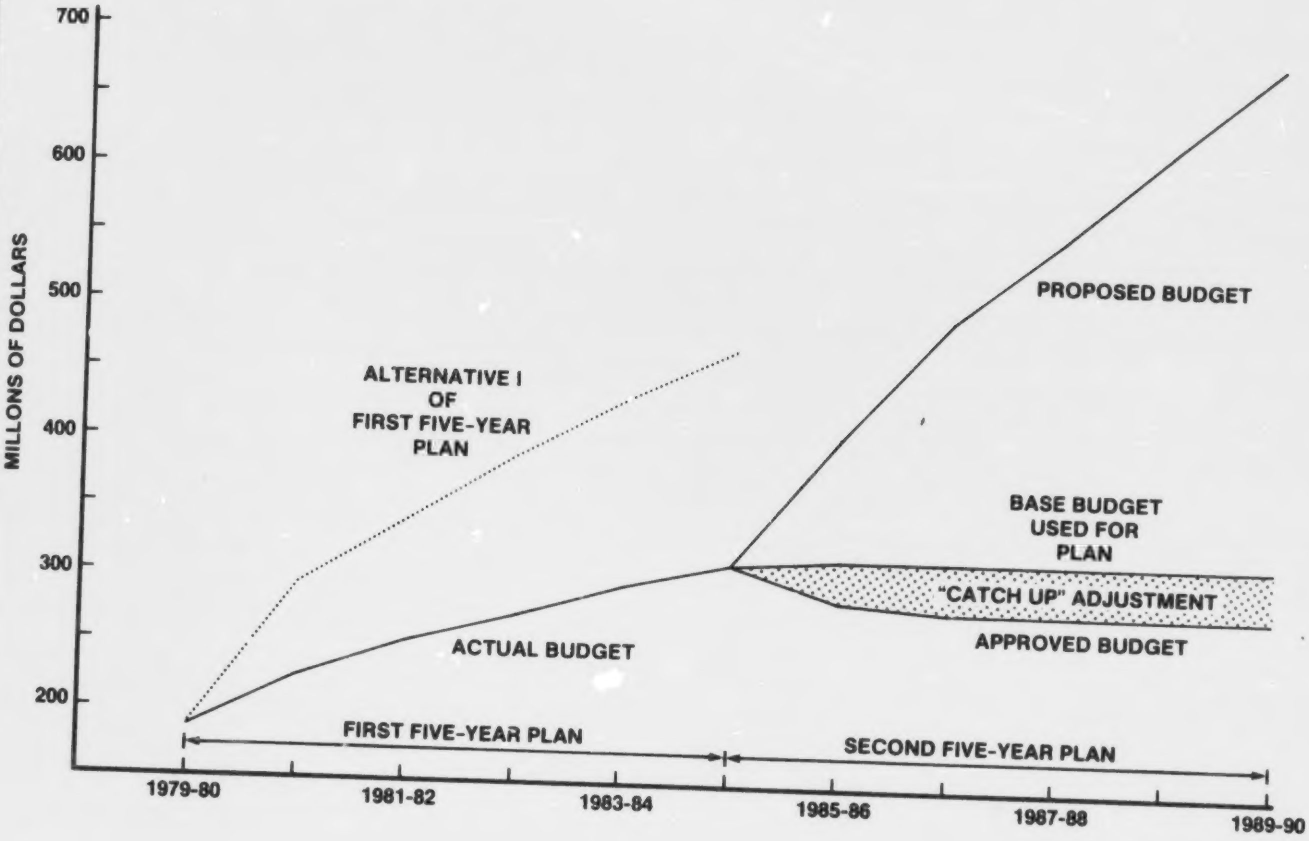
- Annual A-Base increments:	Year 1	122.7-----	----------	----------	----------	----------	
	Year 2		99.7-----	----------	----------	----------	
	Year 3			62.0-----	----------	----------	
	Year 4				68.9-----	----------	
	Year 5					69.1	

Figure D

Required Investment for the Recommended Plan of Action
(millions of constant 1984-85 dollars)



24. The Council is cognizant of the magnitude of the funding request associated with the Recommended Plan of Action, especially given the move to restrict federal government expenditures and to get the overall budget deficit under control. However, economic growth must be stimulated as part of the overall fiscal plan, and research and development and human resources have been specifically identified as key ingredients of such growth. Given the very fundamental role played by the university sector in both research and research training, the Council is of the view that this Plan must go forward with its strong endorsement; it is a prerequisite for the government's repeated targets for increased R&D and for economic growth premised on "R&D, Innovation and Technology Diffusion".

25. During the past five years NSERC was able to achieve a cumulative real increase in its budget of almost $415 million (in constant 1984-85 dollars), but almost half of that came from the first decision taken back in 1979. During that same five-year period the ongoing resource psyche of this nation is reflected in the multi-billion dollar commitment to frontier exploration through the Petroleum Incentives Program (PIP) of Energy, Mines and Resources, Canada. **The incremental investment being sought by this Plan over the next five years for the existing and future research talent of this country is indeed impressive and well beyond past experience; however, the total five-year incremental investment is $200 million less in real terms than the one-year investment in frontier exploration through PIP in 1983-84 alone.** NSERC contends that that is the context within which this Plan should be assessed; are we really prepared as a nation to decrease our overwhelming dependence on depleting physical resources and to turn our attention increasingly towards a world where we must survive largely on the basis of our intellectual capacity? That will be the test of this Plan, and that will also be a critical test of this nation and its resolve to start that change of emphasis. This Plan is very much part of the process of laying down the foundation and preparing the way; it is very much "The Bridge to the '90s".

INTRODUCTION

In June of 1979, just over a year after its creation, the Natural Sciences and Engineering Research Council (NSERC) presented its first Five-Year Plan to the federal government. The Council proposed a major effort designed to restore confidence and continuity to university research efforts, to increase the degree of relevance of that research to national needs, to correct the severe obsolescence of the available research equipment and, of greatest importance, to produce more of the skilled researchers required to bring this nation to a reasonable level of research and development literacy.

Much has been accomplished over the intervening period. This second Five-Year Plan begins with a retrospective look at what has been achieved. The relevance of the initiatives taken over the last five years to today's new circumstances is then assessed and "mid-course corrections" suggested. Finally, a total package is presented as a Five-Year Plan for the second-half of this decade. This will be a critical period because the universities in Canada will be faced not only with an aging professoriate but, more than likely, with continued severe funding shortages at a time when their role as research institutions will become vital and when the need for the products of their graduate schools will be urgent.

The second Five-Year Plan addresses these issues and challenges. It has been prepared at a time of greatly increased awareness by the various sectors of the economy of the importance and value of investments in university-based research, but also during a period of great uncertainty over the respective roles of the federal and provincial governments in the funding of post-secondary educational institutions. It is a fact that the research and development effort at the universities is the first to suffer from funding reductions and therefore the ongoing vitality of that effort rests to a very large extent on the impact of possible changes to the Established Program Financing (EPF) formula.

Be that as it may, the planning process of NSERC cannot wait for a resolution of the EPF negotiations. Accordingly, the second Five-Year Plan advocates two important new initiatives involving expenditures, which, historically, would have been met largely by the universities themselves. The fact that university budgets have not kept pace with enrolment trends, and the subsequent erosion of university spending on R and D, have intensified the need for outside funding to meet the costs associated with supporting a reasonable level of R and D infrastructure and developing a younger and larger community of competent research professors. The Council has had no choice but to analyse the needs, to suggest effective programs to meet those needs, and to assume that federal government funding will be available to fill the destructive vacuum that has developed in the financing of university-based R and D.

All sectors of the economy are increasingly aware of the importance of the longer term nature of much of the university research effort and of its unique research training role. It is not by chance, for example, that this nation's greatest concentration of talent in the emerging field of biotechnology is found within the university community. Such talent does not exist because the market-driven forces of industry or of governments identified biotechnology as a priority sector during the past decades - they did not. Rather, this depth of expertise exists because research challenges were identified and pursued by individual university professors long before biotechnology became a buzzword. University research, pursued as "free enquiry", is this nation's assurance that it will continue to be able to expand the frontiers of knowledge and technology development, and have the skilled minds required to adapt and apply Canadian and imported technology for the economic well-being of the nation.

This second Five-Year Plan advocates a greater collectivity of effort between the university and industrial communities. Accordingly, the final word in this "setting of the stage" is given to two eminent industrial spokesmen:

> The first, from Canada, Mr. Walter F. Light, former Chairman of Northern Telecom Ltd:
>
> "The emerging source of basic economic strength for any society is not capital investment or natural resources, as important as they are. It is brain power. Our industrial society is now brain-intensive. It centers on knowledge which creates sophisticated products and manufacturing processes, while framing the techniques of management itself.
>
> And yet, some of our greatest schools are faced with inadequate or obsolete facilities and equipment, particularly in the key science and engineering disciplines. There is an increasing, and increasingly critical, shortage of the brightest young minds choosing to become teachers and researchers. Universities face the constant threat of declining revenues and financial support from government, business and alumni, to further exacerbate an already desperate situation.
>
> Canada is not just facing a shortage of engineers. It is facing a potentially crippling shortage in almost every body of knowledge we will need in the next two decades. And, the next two decades could decide whether Canada survives as a modern, viable, international, industrial power in the Information Age."(1)

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(1) "Brainpower: Our Neglected Resource", April 26, 1984

The second, from the United States, Mr. Roland W. Schmitt, Senior Vice-President, Corporate Research and Development, General Electric Co.:

"The most important role for government in creating the conditions for commercial innovation is to support universities in their efforts to generate research and provide manpower. The most crucial issue we face is a lack of skilled manpower, a shortage of faculty in universities for training that manpower, and a deteriorating research capability in our great universities because of the shortages of both faculty and modern equipment for instruction and for research.

Universities should not have to compete head on with national laboratories for mission agency funds. Unless the national laboratory will do a substantially better research job, the university should get the funds. The same holds for government funding of research in industry. Those funds that advocates of industrial policy propose to invest in government-directed industrial R and D would normally be much better spent in universities, unless there is a special reason why an industrial laboratory can do it much, much better."(1)

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(1) "National R & D Policy: An Industrial Perspective", Oct 10, 1983

SECTION 1

THE LAST FIVE YEARS

In any ongoing endeavour, it is essential that one pause occasionally to contemplate the results of the course that has been taken, the progress achieved and the impact of changing circumstances. Only then can a renewed and appropriate course be charted. This Section of the second Five-Year Plan presents such a review; it provides what, in effect, is NSERC's "report card" on the expenditure of over $1.2 billion since 1980-81, the first year of the Council's original Five-Year Plan.

A corporate effort of any type should be assessed in light of the program objectives that were established and the adequacy of the resources that were received. NSERC's 1979 Five-Year Plan identified four major challenges:

- "Meeting the Manpower Needs"
- "Providing the Research Tools"
- "An Expansion of Targeted Research", and
- "Maintaining the Foundation (of free enquiry)"

These areas will be assessed both separately and collectively, as the whole 1979 Plan was premised on their strong degree of interdependence. To begin with, however, an overview of the funding situation over the five-year period is presented.

CHAPTER 1

THE WHEREWITHAL

There is no need at this point to repeat the detailed assessment which led up to a costing of the first Five-Year Plan. Suffice it to say that the identification of the major challenges, and the estimates of the investment required for the remedies, have stood the test of time exceptionally well. If anything, the programs embarked upon by NSERC are even more essential now than they were in 1979. There is little doubt that the full funding requested at that time could have been effectively used by the Council and would have better prepared this nation for the expanded R&D effort now being proclaimed.

Table 1 presents the funding level called for in the recommended "Plan of Action" (Alternative I) and the fall-back options (Alternatives II and III). Also presented are the actual expenditures made by the Council over the same period. The comparison is made in constant 1984-85 dollars.(1)

Table 1

Proposed and Actual NSERC Budgets (1980-81 to 1984-85)
(millions of constant 1984-85 dollars)

		First Five-Year Plan				
	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Alternative I	188.7	293.8	342.6	390.1	432.0	470.3
Alternative II	188.7	271.0	308.7	346.5	382.9	415.0
Alternative III	188.7	249.9	283.6	311.3	338.4	363.5
Alternative III (revised)	188.7	227.2	265.7	304.2	342.7	381.2
Actual Expenditures	188.7	227.2	252.3	272.1	295.2	311.6

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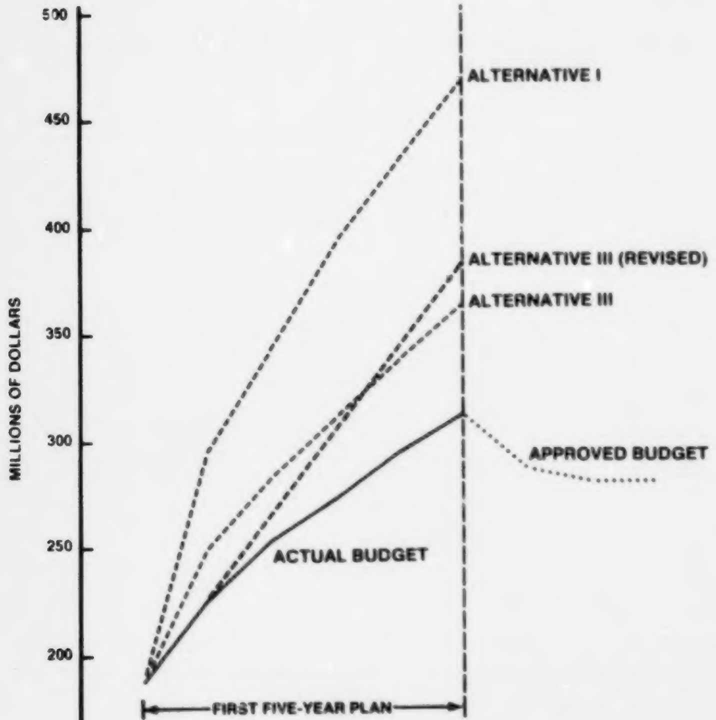
(1)Unless otherwise indicated, conversions from current dollars into constant 1984-85 dollars throughout this document are based on the following inflation factors: 11.7% in 1980-81, 11.6% in 1981-82, 12.7% in 1982-83, 6.0% in 1983-84 and 5.0% in 1984-85.

Unfortunately, but not unexpectedly, the federal government's budgetary circumstances precluded any real consideration of the preferred funding level (Alternative I). However, the initial funding increment approved for 1980-81, did provide some hope of achieving Alternative III. In fact, if the equivalent of that first increase had been repeated in each of the subsequent five years, the total incremental funding so provided would have equated to that of Alternative III (this option is referred to as "Alternative III (revised)" in Table 1). Encouraged by this prospect, Council proceeded with the implementation of the Plan on the premise that this modified Alternative III funding might be realized.

While very significant budget increases were eventually realized, Figure 1 indicates how funding continued to fall short of Alternative III. It became apparent to the Council as it entered the second year of the Plan that some of its proposed initiatives would have to be deferred and others cut back from optimal levels. These decisions are discussed in later sections of this report.

Figure 1

Proposed and Actual Funding Levels of First Five-Year Plan - Total Budget
(millions of constant 1984-85 dollars)



It is important that one look beyond the comparisons presented by Figure 1. No matter how they are measured, the funding increases provided to NSERC have been substantial, particularly in view of the general economic and fiscal situation existing during that period. However, the effectiveness of those new resources was significantly affected by two factors:

- the timing of the funding decisions, and
- the continuity of the funding.

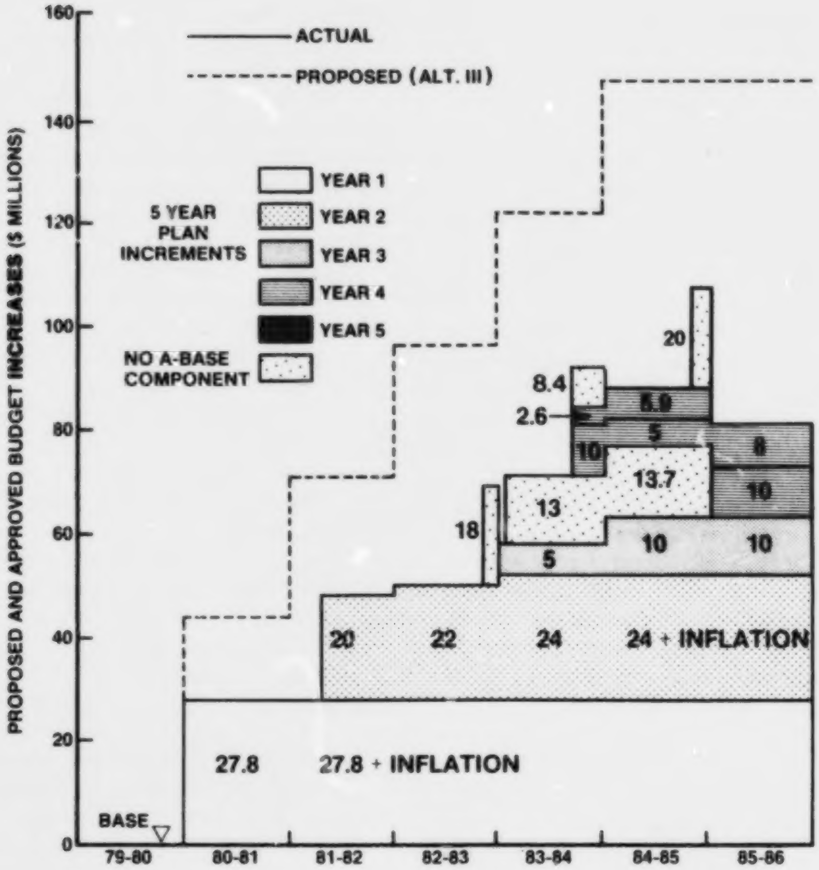
Unfortunately, both of these factors have been fraught with uncertainty. Consider first of all the timing of funding decisions. The optimal year-by-year timing would be to have the subsequent year's budget approved for inclusion in the Main Estimates for that year, i.e. at least five months **before** the beginning of the new fiscal year (April 1). However, only once in five years did that optimal situation occur. During the other four years, the Council entered the new fiscal year with no assurance that the required increments of funding would be forthcoming. In fact, on three separate occasions increments for a particular fiscal year were announced within two months of the **end** of that fiscal year. Clearly, the timing of the decisions has not been optimal and the Council has, of necessity, had to develop a flexible budgetary process to minimize the impact of this uncertainty. For programs requiring commitments early in the fiscal year or multi-year commitments, Council assumed that the funds would eventually be forthcoming. This approach permitted Council to protect the critical need for continuity in its multi-year initiatives. Unfortunately, it also had the effect of forcing Council to consider the "one-shot" support of equipment as a "swing item", i.e. one that would suffer severely if the required funds did not eventually materialize. Although such a crisis situation never did arise, Council came within 45 days of losing this enforced budgetary gamble in two separate years.

Over the period of the five years, NSERC has also had to face increasing uncertainty as to the level of its ongoing budget. Thus, two short-term budget increases received in 1983-84 and 1984-85 expired at the end of 1984-85 resulting in a significant drop in approved budgets for subsequent years (See Figures 1 and 2). This casts a cloud of uncertainty over programs that require continuity to be effective. One cannot do good research, or effectively train future researchers, with an intermittent application of funds.

Figure 2 is a graphical presentation of the budgetary increments provided to Council over the past five years. The situation has become so complex that it almost defies description. Suffice it to say, the funding of NSERC's first Five-Year Plan proceeded well in years one and two, but subsequently became fragmented and short-term. This "patchwork" approach to funding is hardly appropriate for programs that must be successful if Canada is to have the new knowledge and human resources to compete effectively in an increasingly technological world economy. It certainly doesn't project a message of national commitment to those considering research and development as a career option.

Figure 2

Budget Increments Provided by Government



The preceding is not meant to be a litany of complaints about underfunding. It is simply a factual presentation of what was seen as required, what was actually received, and how and when it was received. In spite of the problems, the overall budget increase has been substantial and the Council has employed it in the most effective way possible. Table 2 and Figures 3 and 4 show that the allocation of the new funds has followed quite closely the priorities identified by Council in the Five-Year Plan.(1) The major variations from the 1979 projections can be explained as follows:

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(1) It should be noted that the distribution of expenditures as shown in Table 2 follows the new classification adopted for the next Five-Year Plan in order to allow meaningful comparisons of support levels, trends, etc. The new classification is different from the one shown in the first Five-Year Plan document or in the Reports from the President for those years.

- **Research Manpower Programs:** Alternative III of the Five-Year Plan contemplated a major program of support through "Research Professorships". Given the reduced funding level, this program was deferred and Council focussed its resources on the programs designed to attract more young people into a research career.

- **Research Infrastructure:** Subsequent to the writing of the first Five-Year Plan, a detailed review of the research equipment situation at 16 universities identified a level of obsolescence and disrepair that was even worse than expected. Accordingly, a larger portion of the total budget was devoted to resolving this problem.

Table 2

Summary of Expenditures
(millions of constant 1984-85 dollars)

		First Five-Year Plan				
Activity	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Research Manpower Training	19.3	27.0	33.5	38.3	45.7	51.4
Research Infrastructure	19.6	37.4	49.0	50.2	48.1	33.1
Discipline Research	114.5	116.7	119.9	126.6	135.9	143.0
Targeted Research	18.7	27.3	29.6	32.0	40.7	46.4
Research Development	3.2	3.1	3.7	3.6	3.9	3.1
General Programs	9.8	11.0	11.3	15.0	14.1	23.6
Total Program Expenditures	185.1	222.5	247.0	265.7	288.4	300.6
Administration	3.6	4.7	5.3	6.4	6.8	11.0
Total Expenditures - in constant dollars	188.7	227.2	252.3	272.1	295.2	311.6
- in current dollars	120.7	162.3	201.1	244.4	281.2	311.6

Figure 3

Share of Cumulative Real Growth
1979-80 to 1984-85

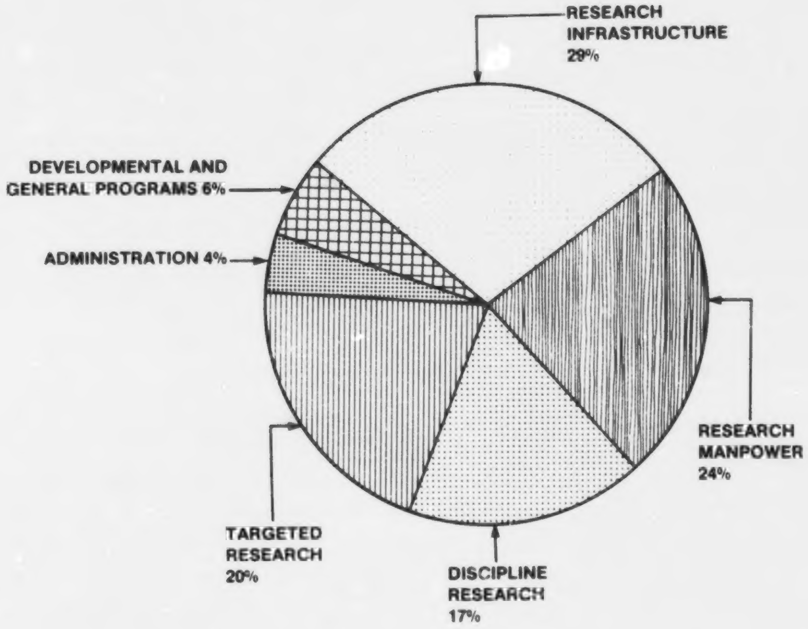
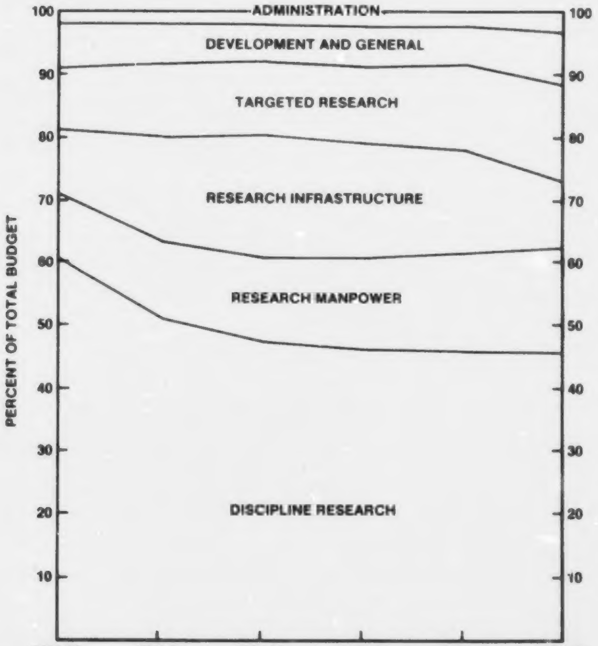


Figure 4

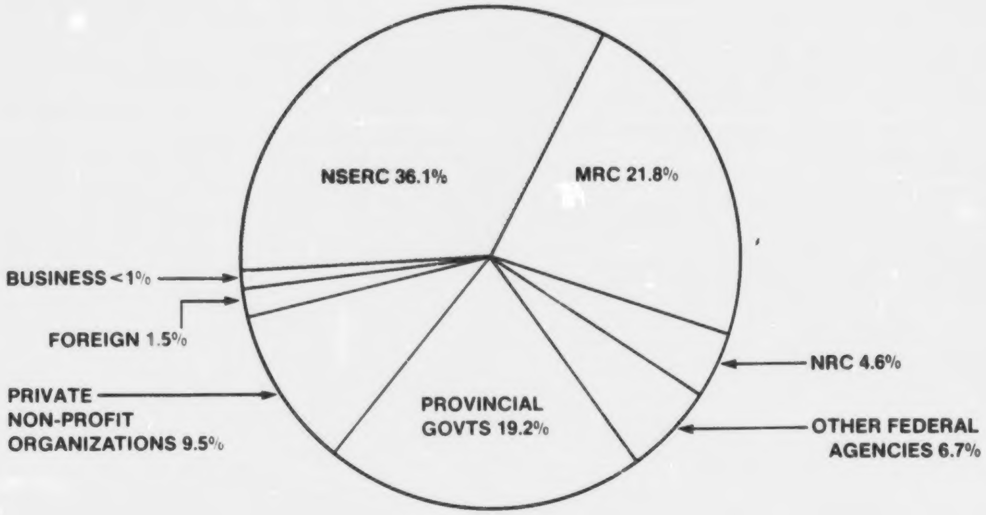
Distribution of Expenditures During the First Five-Year Plan



Finally, it is perhaps useful to view NSERC funding trends in a broader context. Figure 5 illustrates NSERC's leadership in the total external funding of university R&D in the natural sciences and engineering; Figure 6 presents NSERC funding in the context of all direct federal R&D support; and Figure 7 expresses the NSERC program expenditures as a percentage of Gross National Product.

Figure 5

External Research and Development
Support for Canadian Universities 1984-85
(Natural Sciences and Engineering including Medical Research)(1)



TOTAL SUPPORT $656 MILLION

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(1) Sources: Federal Government support from "Federal Government Expenditures on Activities in the Natural Sciences, 1963-64 to 1984-85" (Table 27, p.50). All other funding sources from Statistics Canada, "Resources for R&D in Canada 1982 (with Forecast to 1984)", (Table 16, p.90)

Figure 6

Federal R&D Expenditures, NSE, 1984-85

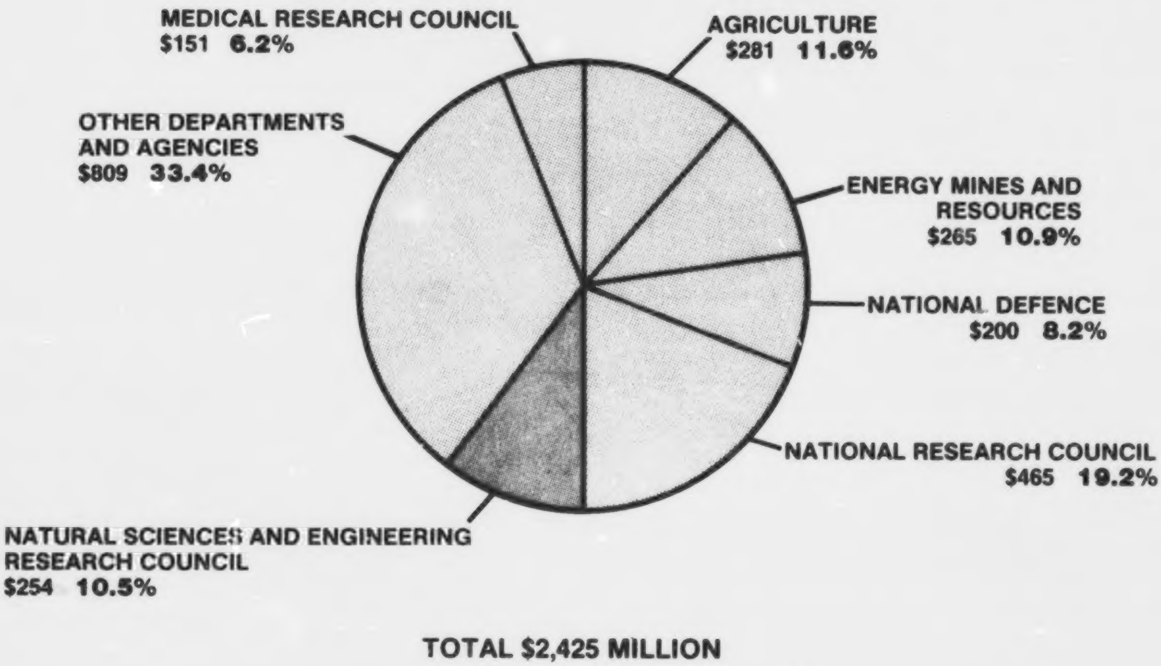
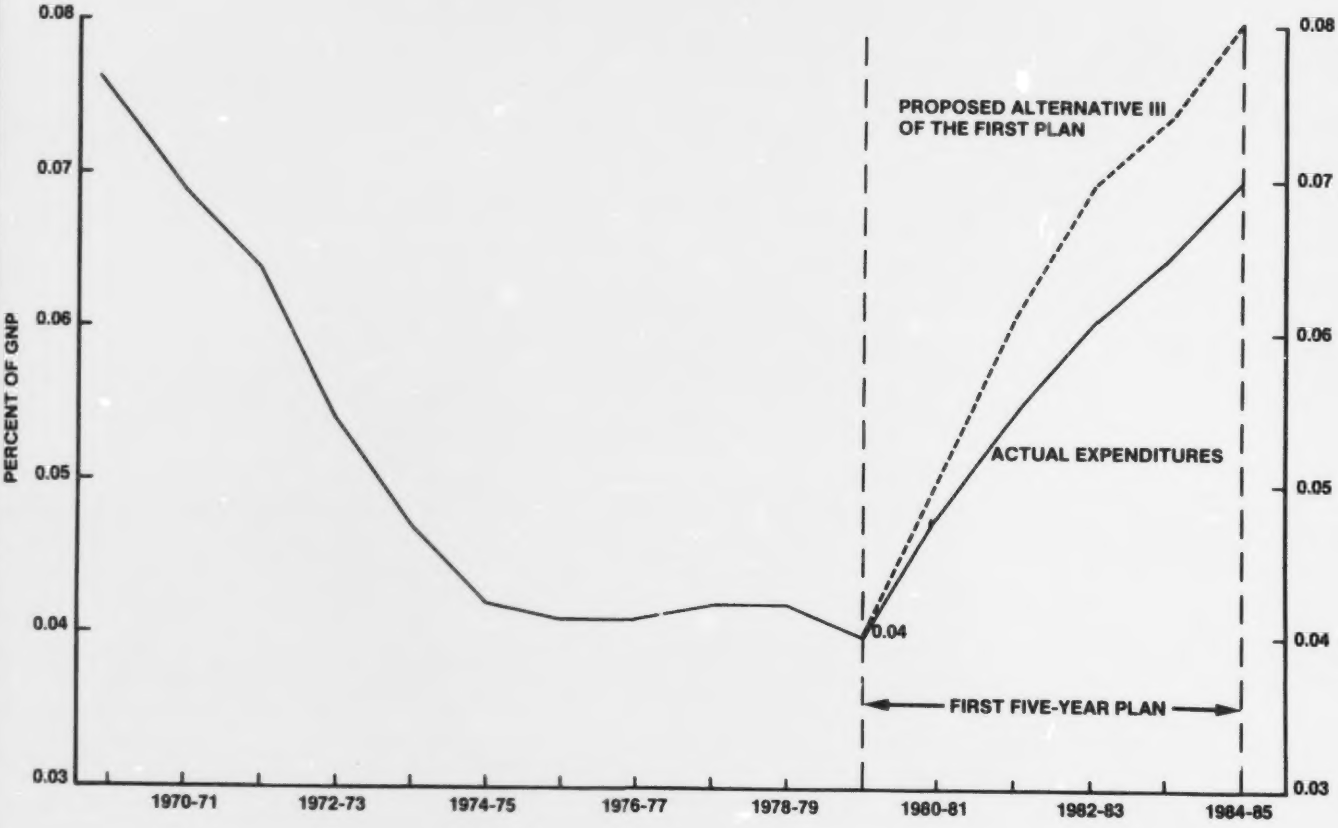


Figure 7

NSERC Program Expenditures as a Percentage of Gross National Product (GNP)



Given this overview of the wherewithal provided to NSERC for pursuit of its Five-Year Plan, we proceed to an evaluation of what has been accomplished.

CHAPTER 2

MEETING THE MANPOWER NEEDS

The first Five-Year Plan was prepared during a period when successive governments were advocating 1.5% and 2.5% of GNP as appropriate targets for R&D investment by the mid 1980s. Both targets called for large increases in research efforts, which in turn, increased the demands for R&D specialists. NSERC's analysis concluded that neither target could be met within the specified time frames because of inadequate numbers of qualified researchers. Furthermore, it was highly unlikely that the deficit in research talent could be met by immigration and the situation was expected to worsen in the early 1990s due to a rapidly increasing rate of retirement of the current research work force. The first Five-Year Plan thus set forth a series of programs designed to help overcome this very fundamental impediment to our national R&D aspirations.

Before summarizing the results of NSERC's efforts, three points must be highlighted.

- NSERC's programs were not intended to meet the **total** projected need; they were planned as a major and essential contribution aimed at producing the future leaders of research and development teams.

- The programs were by no means restricted to the short-term, five-year projection; the need and the results of the investment projected well into the next decade.

- NSERC recognized that the whole university research climate had to be improved before the best young Canadian students could be attracted to the graduate schools of this nation. The success of NSERC's research manpower initiatives depended to a large extent, therefore, upon the success of the Council's other programs.

An overview of the existing research manpower programs is shown in Table 3 and Appendix I analyzes in considerable detail the changes brought about by NSERC's efforts during the period of the first Five-Year Plan. Included in that Appendix are references to an evaluation study carried out by independent consultants. The Council's efforts, extending from the undergraduate to the assistant professor level, are summarized on the following pages.

Table 3

Overview of Existing Research Manpower Training Programs

PROGRAM	OBJECTIVES	FORECAST NUMBER OF AWARDS HELD IN 1984-85	COSTS OF AWARDS HELD IN 1984-85 (thousands of current dollars)
Undergraduate Student Research Awards	To stimulate the interest of undergraduate students in research by providing them with valuable experience in an industrial or university laboratory, and to encourage them to undertake graduate studies.	2,513	7,107
Postgraduate Scholarships	To assist in the provision of highly qualified manpower by providing financial support to excellent students working towards a higher degree in the natural sciences and engineering.	2,703	30,143
Postdoctoral Fellowships	To provide recent doctoral graduates with an opportunity to add to their experience by engaging in specialized research training in universities and research institutes in Canada or abroad. (Excludes NATO fellowships.)	165	3,554
University Research Fellowships	To expand career opportunities for promising researchers and, in so doing, to assist in maintaining the level of university R & D and in maintaining an adequate supply of highly qualified researchers in Canadian universities in anticipation of future demands for new faculty members.	279	7,751
Industrial Research Fellowships	To encourage highly qualfied PhDs in engineering and science to seek careers with industrial organizations in Canada, thereby promoting transfer of technology, assisting Canadian companies in developing improved R & D capabilities, and providing opportunities for future faculty members to gain experience in an industrial environment.	175	2,856
TOTAL		5,835	51,411

Undergraduate Student Research Awards

Given the manpower challenge of the 1990s, the Council realized that it had to break with the tradition of dealing only with the graduate schools. It reached back into the undergraduate population in an effort to whet an appetite for careers in research and embarked upon a program of salary support for undergraduates employed in a research environment within universities or industry. While most awards were made for the summer months, many students in "Co-op programs" relied on NSERC's support during their work periods in industry. This mechanism of support was particularly valuable during the recent period of recession.

University-based awards were allocated to each institution on the basis of the success of the researchers in the grant competitions of the Council. Institutions were guaranteed a minimum number of awards to ensure a reasonable distribution to small universities. Allocation within each institution was left to the university administration. For awards held in industry, all eligible applicants have, to date, been given an award. More information on the distribution of these awards is contained in Appendix I.

Table 4 summarizes the numbers of awards made and the funds invested. Real indicators of success will take longer to appear and may never be such that they can be accurately quantified. But consider the following:

- Responses by students to NSERC questionnaires are high in their praise for the program. Even after applying a significant filter to compensate for a possible "Pavlovian" response, it would appear that the exposure to a research environment has been a positive experience and has prompted a large percentage of the students to pursue postgraduate training.

- Responses from both university and industry employers have been very positive. The evaluation study mentioned previously brought forth an 89% response rate from supervisors: 94% of those replying felt that the award holders had made real contributions to the research effort and 98% were either very satisfied (71%) or fairly satisfied (27%) with the program. In the universities, this program has been praised more often than any other of NSERC's manpower initiatives and is always oversubscribed. It has been of particular value at universities where no postgraduate schools exist; professors attempting to undertake research in this type of environment welcome the help of these enquiring young minds and the catalytic effect that these students have on their research projects.

- This is a very productive program that carries with it an element of leverage because it is targeted towards R&D and provides only partial salary support ($750 per month in 1984-85). On average, salary supplements of $400 per month by the employer have been reported; however, some students work without a supplement in exciting research environments.

- NSERC is tracing the career paths of the recipients within the universities. While insufficient time has passed to produce definitive trends, it is encouraging to see a large number of former award holders now applying for postgraduate scholarships and having an above average success rate in that competition.

- The evaluation study has concluded that "the USRA program achieves its objectives to a very high degree" (See Appendix I).

In summary, the program of Undergraduate Student Research Awards gives every indication of being highly successful. Viewed in the context of the plethora of other student "employment" initiatives, it is Council's view that this program stands out favourably in terms of orientation, financial leverage and broad national distribution. The one disappointment has been the relatively slow growth of the industrial program, but that problem seems to be disappearing. More effort on the part of professors to place good students in industry would certainly accelerate this positive trend.

Table 4

Undergraduate Student Research Awards

	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Number of Awards						
Awards held: Industry	--	--	126	248	403	513
University	--	1,000	981	1,444	1,494	2,000
Total	--	1,000	1,107	1,692	1,896	2,513
Target: First Five-Year Plan (Alternative I)	--	3,100	3,300	3,500	3,700	3,100
Financial (thousands of constant 1984-85 dollars)						
Awards held: Industry	--	--	369	731	950	1,366
University	--	2,954	2,880	4,262	4,386	5,741
Total	--	2,954	3,249	4,993	5,336	7,107
Target: First Five-Year Plan (Alternative I)		9,695	10,320	10,945	11,571	9,695

Postgraduate Scholarships

Graduate schools play a vital role in preparing students for productive research and technologically-oriented careers. Given the increasing sophistication of research, and of industry generally, this role will surely continue to grow in importance. Not surprisingly therefore, NSERC's first Five-Year Plan set out to correct a serious weakening of those graduate schools and to increase the number of Canadian citizens and permanent residents opting for postgraduate training.

This effort was pursued on a number of different fronts: by correcting equipment obsolescence so as to give students experience with state-of-the-art technology; by increasing research grants to professors so they can pursue new and exciting (and more costly) challenges; and by supporting students directly through scholarships for postgraduate study. Although there are almost as many postgraduate students supported through stipends paid from NSERC research grants as there are on NSERC scholarships, the students participating in NSERC's program of scholarships represent a large and well documented segment of the total student population at the postgraduate level. Given the prestige of these awards, NSERC scholars also tend to represent the elite of those staying on for postgraduate training.

The challenges that NSERC faced in 1979 will not be reiterated here. Clearly, however, the declining trend in enrolments in graduate schools was hardly conducive to even a modest growth in our R&D efforts. Without corrective action, there could have been no assurance that even the then existing levels of research and teaching could be maintained in the face of anticipated faculty retirements in the early 1990s.

Evidence of the problem, and of the success of NSERC's program of scholarships, is summarized by Figures 8, 9 and 10. They show the growing interest in the Council's programs and the overall increase in postgraduate enrolments at Canadian universities.

Figure 8

Postgraduate Scholarship Applications
(New and Renewals)

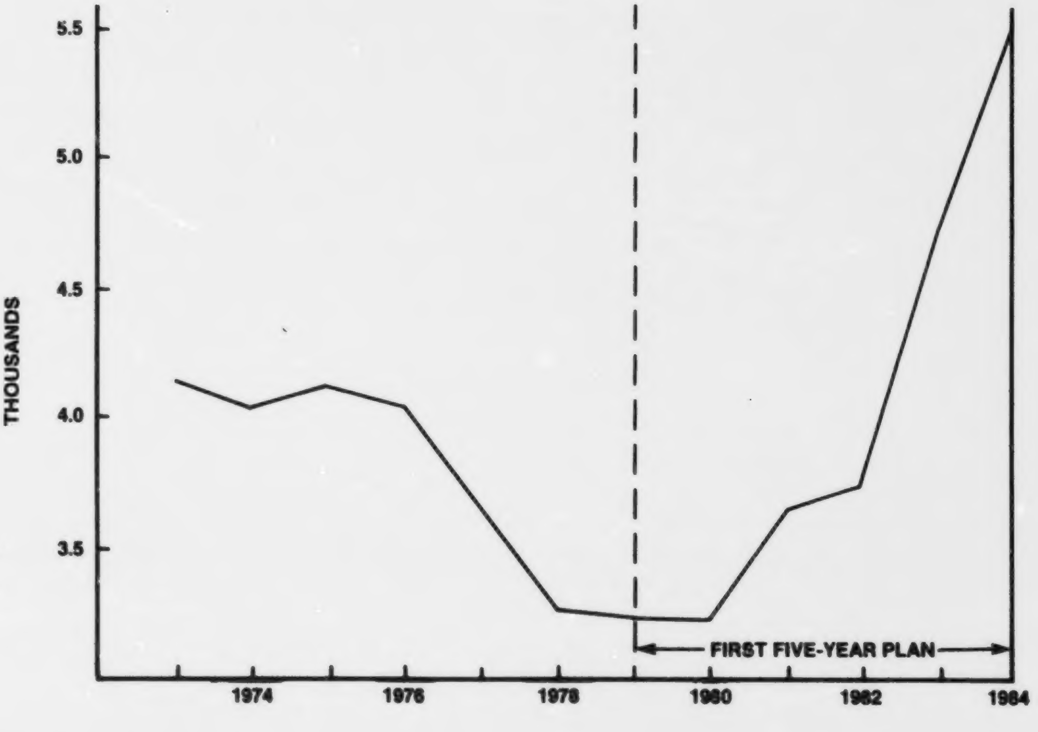


Figure 9

Master's Level: Enrolment and Degree Projections
(Natural Sciences and Engineering)

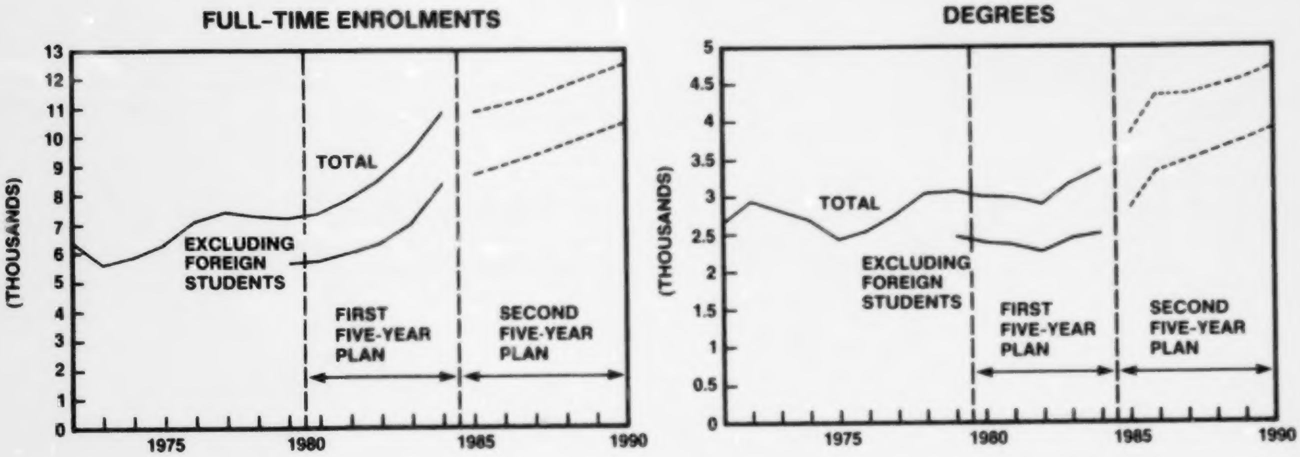
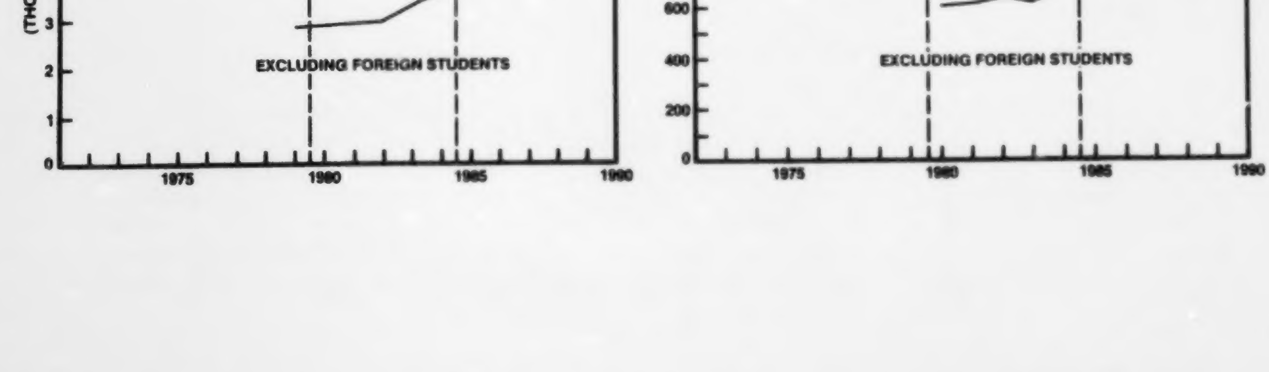


Figure 10

Doctoral Level: Enrolment and Degree Projections
(Natural Sciences and Engineering)



Within the range of disciplines supported by NSERC, there were some fields of graduate study facing extreme difficulty in 1979, especially in the context of resource management and emerging technologies. These "endangered species" were, in order of severity, computer science, engineering and earth sciences. Material presented in Appendix 1 shows that the largest increase in scholarships has been in these important areas.

For obvious reasons, the Council placed a very high priority on its postgraduate scholarship program. Indeed, though the scholarship selection committee was instructed to maintain its tough selection criteria, the Council has, over the past five years, made a point of awarding scholarships to all candidates who could meet those criteria. In addition , Council restored the value of the awards to the purchasing power they had in 1970. As a result, the numbers of awards actually held have exceeded the projections of the first Five-Year Plan (Table 5).

Table 5

Postgraduate Scholarships (1)

		First Five-Year Plan				
	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Number of Awards						
Awards held:	1,461	1,689	1,861	2,011	2,528	2,677
Target: First Five-Year Plan (Alternative I)	—	2,000	2,400	2,400	2,400	2,400
Financial (thousands of constant 1984-85 dollars)						
Expenditures:	15,097	18,226	20,645	22,217	27,705	29,946
Target: First Five-Year Plan (Alternative I)	—	23,767	30,022	30,022	30,022	30,022

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(1) Includes the Council's Postgraduate Scholarships, 1967 Science and Engineering Scholarships, Science Librarianship and Documentation Scholarships, Forestry Scholarships and Special Scholarships

There is no doubt that this program has played a major role in the revitalization of Canada's graduate programs in science and engineering. However, the economic recession of the past three years has also pushed students towards graduate study because of limited employment opportunities. In spite of this undesirable cause, NSERC has viewed the situation as an opportunity to be seized and has acted accordingly. The challenge now is to make graduate work more exciting and rewarding so that the progress achieved to date is not lost as soon as there is a sustained economic recovery.

Industrial Postgraduate Scholarships

While not exactly as proposed by the first Five-Year Plan, this program retains the original objective, namely, to attract some of the best recent graduates back to the universities for graduate studies. This is a cooperative program through which NSERC matches the contribution of the scholar's employer up to the level of a regular postgraduate scholarship (valued at $11,600 in 1984-85). This combined level of support should help offset the loss of salary and advancement opportunities that the employee must face during the two years of study.

The program was launched toward the end of the first Five-Year Plan (November, 1983). As of March, 1985, a total of 34 applications had been received and 27 awards offered (26 held). The participating companies have contributed amounts ranging from $6,000 up to $20,000 toward the students' stipends. One major telecommunications company has developed an internal competition for its professional staff so as to complement the Council's initiative.

The program seems destined to play a modest, but valuable role in the research training initiatives of the Council.

Postdoctoral Fellowships

In most scientific disciplines, postdoctoral research experience is a prerequisite for permanent R&D employment. NSERC recognized the need to support such training and its first Five-Year Plan proposed a four-fold increase of such awards over the five-year period. As indicated by Table 6, this has not occurred, principally because of budgetary restraint. The program was not given the same priority by NSERC as those training initiatives aimed at getting more students into graduate schools. Although the number of applications has increased by over 50% during the five-year period, Council has had to drop the success rate to about 30% (Figure 11).

Table 6

Postdoctoral Fellowships (1)

	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Number of Awards						
Awards held:	101	139	153	144	156	165
Target: First Five-Year Plan (Alternative I)	—	200	300	400	400	400
Financial (thousands of constant 1984-85 dollars)						
Expenditures:	2,061	2,226	2,609	2,900	3,320	3,554
Target: First Five-Year Plan (Alternative I)	—	5,004	7,505	10,007	10,007	10,007

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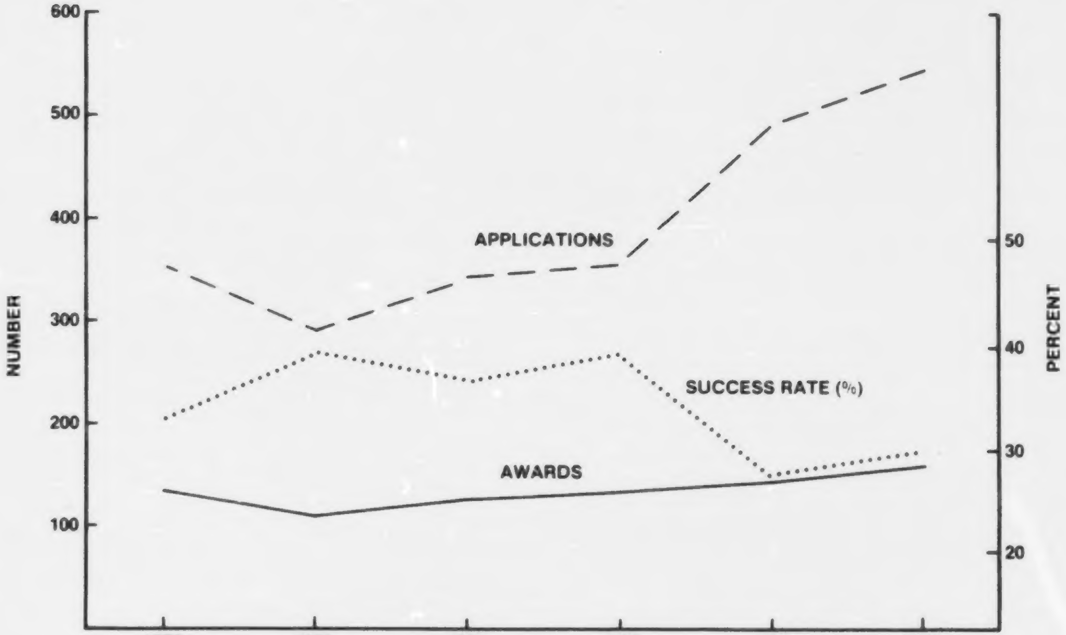
(1) Includes only university Postdoctoral Fellowships. Does not include approximately 25 fellowships awarded each year using NATO funding. Does not include Industrial Postdoctoral Fellowships, a program which has been phased out in favour of the Industrial Research Fellowship Program.

Figure 11

Number of new Postdoctoral Fellowships Applications and Success Rates (1)



*EXCLUDES NATO SCIENCE FELLOWSHIPS AND INDUSTRIAL POSTDOCTORAL FELLOWSHIPS

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(1) Success rates are based on the number of awards offered: the number of awards actually taken up is normally less. The NATO Science Fellowships and the Industrial Postdoctoral Fellowships are not included.

The program of postdoctoral fellowships is not only an essential element of research training, it is also the most frequently used vehicle for expanding a researcher's horizons through work in foreign laboratories. On average about 60% of the awards are held abroad. Obviously, there is a danger of permanently losing this talent to the foreign host country. This issue is addressed in Section II of this report, where it is shown that there is no evidence of a major "brain-drain".

University Research Fellowships

In 1979, NSERC identified and quantified the serious attrition rate of the existing professoriate which will commence in earnest about 1990 and accelerate rapidly through the 90s. This fact, coupled with a lack of faculty positions for young people during the 1980s, translates into critical shortages of professors in the decade ahead. Furthermore, similar situations in almost every western industrialized nation suggest that our past dependence on immigration to alleviate such problems is no longer available to us. (Almost 52% of NSERC Operating Grant applicants in 1984-85 obtained a BSc degree from a foreign country, suggesting that about 52% are immigrants to Canada).

Many other reports have now identified this problem, but to date the Council's program of University Research Fellowships (URFs) stands out as the most significant national effort to help ease the problem. In fact, it is probably the most ambitious program of its type and is recognized as such by NSERC's counterpart agencies participating in the science programs of NATO(1). For many reasons therefore, it is being monitored closely and a comprehensive analysis of results to date is included in Appendix I.

Table 7 summarizes the progress made relative to the objectives of the University Research Fellowships program as set out in the first Five-Year Plan. To date the Council has reviewed a total of 1506 nominations and has offered 356 awards (316 of which have been held). Table 8 shows the current status of the fellows.

Table 7

University Research Fellowships

		First Five-Year Plan				
	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Number of Awards						
Awards held (1)	--	94	159	201	234	279
Target: First Five-Year Plan (Alternative I)	--	100	200	300	400	500
Financial (thousands of constant 1984-85 dollars)						
Expenditures	—	1,254	4,607	5,842	6,785	7,751
Target: First Five-Year Plan (Alternative I)	—	2,815	5,629	8,444	11,258	14,073

(1) Number of persons holding an award for at least part of the year.

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(1) North Atlantic Treaty Organization

Table 8
Status of University Research Fellows
(as of March 1985)

	Year of Initial Award				
	1980	1981	1982	1983	1984
Awards accepted	94	66	50	54	52
Awards terminated to take up non-university positions in Canada	4	3	1	0	0
Awards terminated to take up tenure-track university positions in Canada	9	8	2	1	0
Awards terminated to take up positions in other countries	3	3	0	0	0
Awards terminated by NSERC because of unsatisfactory performance	3	5	N/A	N/A	N/A
Awards terminated by fellows for unknown reasons and destinations	2	1	0	0	0
Number of fellows and former fellows now in tenure-track positions in Canada or with firm commitment of tenure-track position in the near future	54	14	2	1	0

Appendix I presents a short description of the program itself. Suffice it to say here that a University Research Fellow:

- receives substantial salary support from NSERC (up to $30,500 in 1984-85);
- has a non tenure-track position at the assistant professor or equivalent level;
- has reduced teaching responsibilities so that he or she can concentrate on research; and,
- receives an automatic NSERC research grant during the first three years of the award.

In terms of results, the Council is generally pleased, although in many respects it is still too early to judge the degree of success. Those who received their awards in 1980 reach the end of their five-year term on June 30, 1985. At that time, one will be able to assess what percentage of that original group has been able to acquire tenure-track or tenured positions at a Canadian university -- a condition which must be met for continued (and phased-down) support by the Council.

Given the fact that 31% of the successful URFs over the five-year period returned from abroad to take up the awards, the relatively modest loss to date of six fellows to positions outside of Canada was to be expected and is not considered to be a serious problem. The net gain to Canada has been quite significant.

The URF program was meant to respond only to truly outstanding young PhDs and accordingly NSERC has applied extremely rigorous selection criteria. If the Council's total budget had been higher, a few additional awards could have been made, but probably no more than an additional 10%

over the five years. Therefore, the failure to reach the target numbers identified in the first Five-Year Plan is more a result of the strict selection criteria than of budgetary pressures.

In summary:

- the URF program, in its effort to help meet serious faculty shortages in the 1990s through the development of a pool of extremely competent PhDs has aroused significant international interest;
- the quality of the fellows is exceptional; some have already emerged as research leaders;
- there has been a substantial "brain gain" as a result of the program;
- nominating and host universities have generally followed NSERC guidelines although some institutions have clearly approached the program with more thought of immediate benefit to the university rather than of the longer term interests of the research fellow.

Council is firmly convinced that this program must be continued.

Industrial Research Fellowships

NSERC has launched a program that is essentially parallel to the University Research Fellowships program but involves employment within Canadian industry. The Council makes a significant contribution to the salary of young PhDs ($25,900 in 1984) for up to three years. The objectives are two-fold: to assist young professionals to pursue an industrial research career and to assist the sponsoring companies to expand their R&D effort. Table 9 summarizes the awards made to date and the total investment.

Appendix I contains information on sponsoring companies and on the discipline and regional distribution of the awards. It also presents results of a program evaluation indicating that at least 67% of the fellows are confident they will be retained by the host company after the expiry of the fellowship.

However, as the initial awards were made for a five-year period (now reduced to three), it is premature to draw conclusions regarding rates of retention within the host company or within an industrial research environment. In the meantime, the Council is satisfied that productive research employment is being provided that would not otherwise exist, and therefore, the fellow and the company are realizing a significant benefit which should translate into a national benefit. If, however, there should be a low retention rate by industry in the future, this program would have to be rethought.

Table 9

Industrial Research Fellowships (1)

	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Number of Awards						
Awards held (2)	--	27	83	119	144	175
Target: First Five-Year Plan (Alternative I)	--	100	225	375	550	750
Financial (thousands of constant 1984-85 dollars)						
Expenditures	--	3	1,223	2,102	2,463	2,856
Target: First Five-Year Plan (Alternative I)	--	2,815	6,255	10,476	15,480	21,109

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(1) Does not include Industrial Postdoctoral Fellowships which were phased out in favour of this program.

(2) Number of persons holding an award for at least part of the year.

Research Professorships

The Council's first Five-Year Plan had contemplated that its spectrum of manpower programs would be crowned by a number of prestigious NSERC Research Professorships. Although budgets did not permit such an endeavour, the planning and consultation for this program has continued and is presented as part of the supporting material for the next five years.

Summary

The Council has every reason to be proud of what it has achieved in terms of increased research training, as described in the foregoing review and in the program evaluation report. Given the responsive nature of all of the programs summarized in Table 3 and the tough selection criteria employed, the last five years have seen a great improvement in the present and future pool of highly trained research talent. Those who are close to the programs obviously see problems and shortcomings, but these are being addressed and corrected. It is also encouraging to see some complementary provincial programs being initiated, especially in the Province of Quebec. Overall, one sees no reason to cut these programs; indeed, any national R&D effort, or even our ability to use and improve imported technology, will grow only if the required research talent is available. NSERC's programs, while extremely modest in terms of overall funding for technology-related training in Canada, are unique in that they focus on the supply of the future leaders of our overall science and technology effort. They must succeed if we are to have that required leadership.

CHAPTER 3

PROVIDING THE RESEARCH TOOLS

When Council developed its Five-Year Plan in 1979, it had not yet embarked upon a detailed study of the state of university research equipment. But a preliminary assessment, however cursory, of past funding trends, of the useful life of research equipment, of obsolescence caused by technological advances, and of the eroding capacity of universities to maintain such equipment, suggested a problem of serious proportions.

The lack of adequate research tools has negative effects that pervade all aspects of NSERC programs: research productivity suffers because professors spend their time repairing and patching; accuracy decreases; the advantages of state-of-the-art facilities are unavailable; undergraduates sense that there is a lack of priority on research and turn away from graduate studies; and those who do pursue such studies increasingly opt for better equipped foreign graduate schools. That is why the first Five-Year Plan called for a major program of equipment acquisition and a greater role for NSERC in the maintenance of the equipment base. These two related issues are reviewed separately below.

Research Equipment Grants

The major importance of research tools prompted the Council in 1980 to embark upon a detailed analysis of the equipment situation at sixteen universities. The report (1) of the Task Force charged with this analysis documented a problem even more serious than had been forecast in the Five-Year Plan. It also revealed that researchers had become increasingly dependent on NSERC to purchase equipment. Obviously, the Council had to apply a higher priority and therefore a higher percentage of the new funding received to the problem delineated by the Task Force. Indeed, the Task Force judged that it would be necessary to invest the equivalent of $80 to $90 million (in today's dollars) per year in research equipment, not counting operation and maintenance costs. Over the five years of the Plan, therefore, the Council increased its investment by a total of $110 million (in constant 1984-85 dollars) directly through the Equipment Grants program. This represents over 26% of the new funding made available during that period and, on average, about 13% of Council's total program budget. Figure 12 illustrates that the level of equipment funding has exceeded that proposed in Alternative III of the Plan, even though overall funding for that option was not realized.

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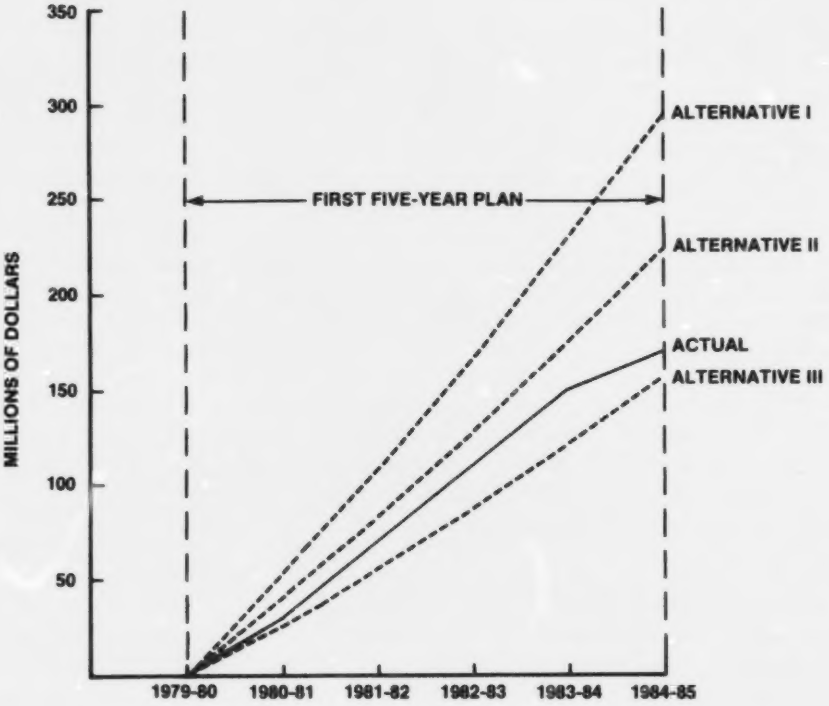
(1) Report of the Task Force on Research Equipment to the President of the Natural Sciences and Engineering Research Council, May, 1981.

Figure 12

Actual and Planned Investment in Research Equipment
(Cumulative Expenditures in Constant 1984-85 dollars)



Equipment grants made by the Council fall into three categories:(1)

- Equipment:	from $7,000 to $125,000
- Major Equipment:	from $125,000 to $275,000
- Major Installations:	greater than $275,000

Figures 13 and 14 show how requests and awards surged in 1981-82(2) as some of the backlog of demand came forward. The number of applications then settled down to a steady growth which culminated in 1,402 applications requesting $98.9 million in February, 1985.(1) Greater detail on competition data is given in Appendix II.

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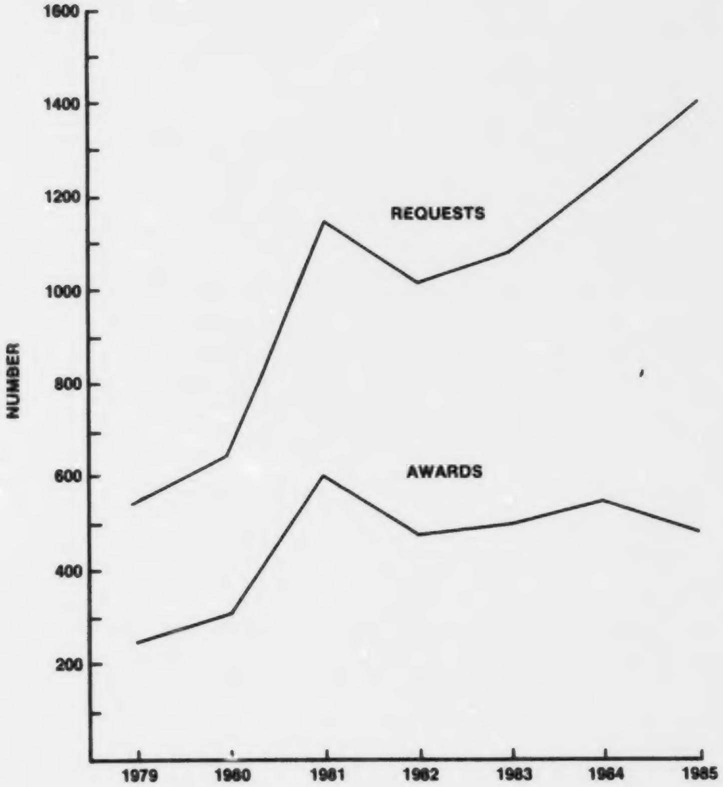
(1) The price ranges for equipment purchase have been modified slightly over the period of this survey to reflect cost increases.

(2) Applications for 1980-81 had already been received by the Council before the Five-Year Plan was approved in November, 1979.

Figure 13

Research Equipment Requests and Awards in Annual Competitions
(Numbers)



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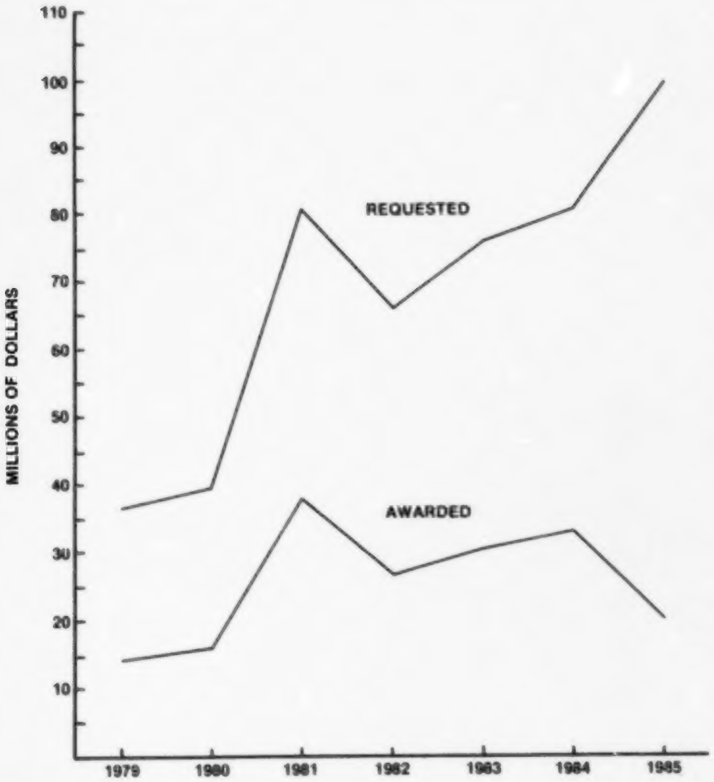
(1) It should be noted that funds awarded in a competition cannot be compared directly with fiscal year expenditures; awards resulting from a competition are often paid from different fiscal year budgets.

Figure 14

Research Equipment Requests and Awards in Annual Competitions
(millions of constant 1984-85 dollars)



Thanks to the budget increases, and to the high priority given to correcting equipment obsolescence, the Council has been able to make very significant progress towards meeting the challenge identified by the Task Force in 1981. It is not, however, a task with a finite beginning and end; rather, it is an ongoing process which will become increasingly demanding as research endeavours become more sophisticated and as the "useful life" of equipment necessary for forefront research becomes shorter and shorter. These and other issues will be addressed in later sections of this report.

Not all disciplines saw their equipment grants increase proportionally to the priority given to equipment by the Council (Tables 10 and 11). This is not surprising, and it is important to understand that there are valid reasons for the variations in requests and thus in awards:

- some disciplines are more dependent on equipment than others; e.g. chemistry vs. mathematics;
- the cost of equipment varies among disciplines, e.g. chemistry requires more expensive equipment than biology;
- in some disciplines a greater portion of the equipment needs can be met through operating grants (i.e. for items of equipment costing less than $7,000);
- for some researchers, other financial needs take priority, e.g. field work in the Canadian north; and,
- not all disciplines request the same level of equipment support from NSERC, perhaps because of the existence of other funding sources.

The Council is fully aware that the Operating Grant itself remains the lifeblood of all university-based research. Having achieved a considerable element of "catch-up" equipment funding in its first Five-Year Plan, Council must readjust the balance between Equipment and Operating Grants in the planning process for the next five years.

As indicated by Table 10, NSERC has been able to respond favourably to 48% of the applications, which in turn represent 42% of the dollars requested over five competitions. (This excludes the competition held in February 1985 when a response rate of only 20% was possible.) At this level of response, most applications rated by peer review committees as excellent and essential were funded. While additional awards could certainly have been warranted, and the funding would have been effectively utilized, other priorities were deemed more urgent. With the 20% success rate in the most recent competition, however, NSERC fell $23 million short of funding equipment applications that were well justified and urgent. This situation is particularly critical for fast-emerging areas of R&D.

In presenting the equipment challenge in its first Five-Year Plan, NSERC also called attention to the fact that a remedial program "... must be well planned, fully discussed with provincial governments and developed so as to provide the greatest possible scope for entry of more Canadian companies into this high technology field". Concerted efforts have been made in this regard.

For example, the report of the Task Force on Equipment was discussed with all provinces before implementation of some of the recommendations. In some instances, especially where duplicate agencies, representatives of those agencies participated in NSERC site-visits and there were a number of instances in Ontario and Quebec of joint funding of large requests.

Table 10

Percentage Distribution of Equipment and Major Equipment Grant Funds (and Number of Grants) by Discipline in Annual Competitions

Discipline	Base Year	First Five-Year Plan				
		(1)	(2)	(3)	(4)	(5)
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Biology	21.0 (27.2)	21.9 (23.1)	18.3 (24.6)	19.4 (29.8)	19.8 (28.8)	19.9 (31.2)
Psychology	2.4 (2.4)	1.2 (2.3)	1.4 (4.0)	1.5 (4.9)	2.1 (5.3)	1.6 (4.5)
Chemistry	23.4 (14.6)	25.0 (15.9)	19.8 (15.1)	21.6 (15.7)	24.5 (14.1)	22.5 (14.7)
Physics	12.2 (15.9)	13.6 (14.3)	18.1 (17.1)	14.7 (12.9)	10.9 (10.0)	14.6 (10.4)
Engineering	25.0 (27.2)	23.4 (30.2)	29.6 (29.0)	26.5 (24.2)	27.1 (27.1)	30.1 (28.1)
Earth Sciences	13.0 (8.9)	9.8 (10.4)	8.7 (6.2)	9.5 (7.5)	8.3 (8.8)	7.2 (7.4)
Comput./Info. Sci.	2.5 (2.8)	2.8 (2.3)	2.0 (2.2)	5.9 (3.6)	4.8 (3.9)	3.7 (2.8)
Math/Statistics	0.5 (0.4)	0.4 (0.6)	0.2 (0.8)	0.4 (0.9)	1.4 (1.4)	0.2 (0.6)
Interdisciplinary	0.1 (0.4)	1.8 (1.0)	1.9 (1.0)	0.4 (0.4)	1.0 (0.6)	0.2 (0.4)
Total Grants:						
• Millions of constant 1984 dollars	10.2	14.4	30.6	21.4	22.8	25.7
• Number of grants	246	308	601	466	490	538
Total Requests:						
• Millions of constant 1984 dollars	32.3	35.1	65.0	53.3	54.5	67.4
• Number of applications	556	637	1126	998	1064	1210
Percent Funding Rate	31.8	41.1	47.2	40.2	41.8	38.2
Percent Success Rate	44.2	48.4	53.4	46.7	46.1	44.5

Table 11

Ratio of Equipment and Major Equipment Grants to Operating Grants for Funds (and Number of Grants) by Discipline*

Discipline	Base Year 1979-80		First Five-Year Plan (1) 1980-81		(2) 1981-82		(3) 1982-83		(4) 1983-84		(5) 1984-85	
Biology	.076	(.055)	.110	(.058)	.194	(.119)	.136	(.110)	.140	(.109)	.148	(.124)
Psychology	.048	(.022)	.033	(.024)	.078	(.077)	.055	(.068)	.076	(.074)	.063	(.068)
Chemistry	.160	(.068)	.248	(.094)	.410	(.172)	.299	(.135)	.349	(.134)	.355	(.158)
Physics	.064	(.059)	.101	(.066)	.285	(.159)	.151	(.090)	.111	(.076)	.170	(.086)
Engineering	.102	(.052)	.132	(.071)	.351	(.130)	.212	(.084)	.202	(.090)	.233	(.098)
Earth Sciences	.141	(.047)	.151	(.069)	.286	(.081)	.206	(.071)	.184	(.087)	.174	(.083)
Comput./Info. Sci.	.060	(.029)	.094	(.027)	.138	(.048)	.264	(.060)	.195	(.059)	.156	(.045)
Math/Statistics	.008	(.001)	.009	(.003)	.013	(.007)	.015	(.006)	.048	(.009)	.007	(.004)
Interdisciplinary	.061	(.111)	1.056	(.250)	1.356	(.273)	.125	(.050)	.330	(.079)	.064	(.059)
NSERC	.090	(.046)	.127	(.057)	.267	(.109)	.176	(.082)	.174	(.083)	.187	(.090)

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* Includes Individual, Team, Project Operating Grants

With regard to increasing the Canadian content of equipment funded, Council is perhaps a leader on the federal scene because of its insistence that applicants address the issue of availability of Canadian products. In many ways, however, these efforts are totally inadequate because of the lack of staff resources to review the applicants' statements and to follow up on the actual equipment eventually purchased with the grant. A more effective effort on everyone's part would be possible if some real degree of monitoring were achieved.

Council strongly encourages Canadian content. However, it recognizes and accepts the fact that the researcher concerned is best placed to decide, on a scientific basis, what is required to do the job effectively. Despite this degree of flexibility and the absence of monitoring, there have been a rapidly growing number of instances where Canadian equipment manufacturers have benefitted significantly from NSERC's efforts. Ironically, the benefits would probably have been greater if the Canadian publishing company which had agreed to produce an NSERC-subsidized catalogue of domestic equipment had been able to do so in a timely and effective manner. This particular undertaking has been fraught with frustrations because of the company's difficulty in attracting the interest of small Canadian firms, even with significantly reduced "page charges" for advertising. Better ways of advising researchers of the availability of Canadian equipment and supplies must be found. But one must also be realistic and understand that many large instruments essential, for example, in every department of chemistry or computer science, are simply not made in Canada. Thus, although it is possible to improve on Canadian content, it would not be realistic to hope for a large percentage share; the worldwide market is simply too small to sustain local manufacturers in many countries. On the other hand, development and installation of major facilities in Canadian laboratories, even with components obtained from non-Canadian sources, results in significant employment for Canadians, ongoing service contracts and, on occasion, technological spin-off to local industry.

Like all of Council's programs, the equipment granting activity will be subjected to a detailed evaluation by independent specialists. However, because that review is not scheduled until 1986, a partial internal assessment was carried out by staff retained for that purpose. The analysis was limited to major equipment and major installation awards, as neither staff resources nor time were available to properly assess the overall merits of the 2646 "regular" equipment awards made over the past five years. Appendix II of this report presents the conclusions of this in-house review.

In summary, there is no doubt that the funds allocated by NSERC to address the equipment challenge were desperately needed. Equally, there is little doubt that the funds available through NSERC were increasingly becoming a larger and larger percentage of the total funds available for equipment from all sources. The same applies to the cost of operating and maintaining the equipment as will be described later. Unfortunately, the equipment funding problem that Council is trying to alleviate is being exacerbated rather than eased by the imposition of provincial and federal sales taxes and import duties. NSERC's efforts could be assisted greatly by more flexible and supportive policies at both levels of government without any damaging effect on the potential for Canadian content.

Infrastructure Support

It is obviously a futile exercise to fund expensive new research equipment if the financial resources are not available to hire competent technicians to operate and service that equipment. NSERC's first Five-Year Plan correctly forecast a growing and serious problem in this regard:

> "University funds for the provision of technical support services for the operation and maintenance of research equipment have been shrinking to the extent that the present efficiency of use of major equipment is generally in the 50 percent range. As a result, the effectiveness of the researcher who is dependent upon the use of that equipment is severely reduced.
>
> The effect of insufficient technical staff will become progressively worse, even if the universities are able to maintain the current level of research support services. The aging of the faculty will be accompanied by an increase in the demand for technical support staff.
>
> It is estimated that in order to achieve the full potential of their capital and intellectual resources, universities would have to double their current technical support staff. However, today's trends in the universities' financial situation appear to be going in the opposite direction at such a drastic rate that over the next five years university support for technical support services may well be cut in half, perhaps to zero in some provinces."

This problem has grown even faster than was envisaged in 1979, but Council has lacked the funding to respond even to the level called for by that first Plan, i.e. ongoing "infrastructure" funding equal to 12% of "net program budgets".(1) For similar reasons, the Council was forced to reject a recommendation of the 1981 Task Force on Research Equipment that NSERC greatly expand its Infrastructure program. In the meantime, however, the situation has become so critical that some universities are hesitant to endorse requests to NSERC for major equipment; they lack the funding to provide the space and air conditioning frequently required and have little or no provision for technical support services. Accordingly, a major initiative in this regard is now deemed essential and a proposal is developed in Section III of this report.

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(1) "Net program budget" is the total program budget less industrially-oriented manpower awards and equipment awards.

Over the past five years, NSERC was able to expand its direct support of research infrastructure by only a modest amount. This support was limited to specialized needs that would not normally be funded from Operating Grants or from user fees. Furthermore, the Infrastructure Grants program was extended to include salary support for groups of specialists required by a number of researchers for ongoing research endeavours (e.g. computer programmers), not just equipment maintenance and operating costs. The program also supports marine science institutes such as the Western Canadian Universities' Bamfield Marine Station, which in previous years were funded through special grants. It also funds a limited number of field stations. Table 12 records the growth of this type of support over the past five years and also shows that the computer science community has been one of the major beneficiaries of the expansion of this program.

However, the infrastructure needs of the university research community have grown well beyond NSERC's ability to fund them. The modest expansion of Council support has helped, but the need, as will be documented later, is out of all proportion to existing levels of funding.

Table 12

Expenditures Through the Infrastructure Grants Program (1)
(Thousands of constant 1984-85 dollars)

		First Five-Year Plan				
Discipline	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Biology	1,176	1,237	1,314	1,660	1,796	2,125
Psychology	44	80	79	80	80	120
Chemistry	37	36	73	258	400	639
Physics	5,075	5,371	5,360	5,187	5,470	5,291
Engineering	403	353	373	599	1,116	1,937
Earth Sciences	365	235	254	377	610	1,024
Comput./Info. Sci.	165	162	174	445	1,093	1,288
Math./Statistics	156	168	29	118	151	240
Interdisciplinary	81	80	107	126	19	64
Total	7,503	7,722	7,763	8,851	10,735	12,728

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(1) Prior to 1982-83, the awards were made under the Core Grants Program.

Summary

The Council has made a major and effective effort to reduce the critical level of obsolescence in university research laboratories. Equipment and infrastructure support have consumed 29% of the new funding provided over the past five years. Effective and efficient research will demand a continuing emphasis on the purchase of state-of-the-art equipment; furthermore, either Council or the universities themselves will have to fund to a much greater extent the infrastructure and personnel needed to support the research equipment and the research effort itself.

CHAPTER 4

DISCIPLINE RESEARCH - THE FOUNDATION OF THE TOTAL EFFORT

NSERC's highest priority has been, and remains, the Discipline Research programs in which most awards are made to individuals, on the basis of excellence, and for on-going research activities rather than for specific projects of limited duration. Discipline Research grants accounted for 48% of NSERC's total program expenditures in 1984-85 (details in Appendix III). They consist of: Operating Grants and E.W.R. Steacie Memorial Fellowships. Operating Grants in turn, include: Individual, Team, Project (in subatomic physics) and Coop (now phased out) Grants as well as research grants to University Research Fellows. Operating Grants are truly the sustaining force for all university research in the natural sciences and engineering in Canada. Without the competition for excellence that this program promotes, and without the continuity of funding that it provides to productive researchers, the ability of the university community to respond to more targeted research, to contract work and to increased university-industry interaction, would be seriously undermined.

Although not very descriptive, the term Operating Grant is well understood within the university community; indeed, these grants are the standard by which overall research capability is frequently measured. However, to the uninitiated, the term is difficult to understand. For this reason, the following brief description of the Operating Grant program is presented, along with comments on its role in the support of research and development and R&D training.

- Applications are reviewed by one or more of NSERC's nineteen peer review committees, each of which is responsible for a major discipline area, for example animal biology, civil engineering, chemistry, etc. These groups of experts, with the assistance of external referees, make grant recommendations to the Council.

- The review of applications concentrates on:

  a) the recent research record of the applicant; and,
  b) the quality of the research proposal itself.

- There is no special treatment of "priority" research areas premised on currently perceived national or industrial need. The emphasis is on the significance and importance of the research objectives and the likelihood of their being realized. Other considerations relative to engineering research are mentioned later. (see Chapter 6)

- In all but Project Grants in subatomic physics the researcher, once supported by a grant, is free to alter the research endeavour in any way and at any time during what is normally a three-year grant period. Thus, these grants support what is truly "free" or "curiosity-driven" research, words which, unfortunately, all too often carry a disparaging connotation of waste or frivolity. Nothing could be further from the truth. It is this unfettered pursuit of new knowledge and its application that provides the necessary base for future advances and technological developments in both the short and long-term. Those research programs which are not productive, or lack the expected component of innovation are quickly identified by the peer review committees and funding is reduced or terminated. Given the important role of Operating Grants in establishing both a research and an academic career, a researcher will plan the expenditure of such a grant with the utmost prudence. Indeed, the pressures on the researcher, combined with an ingrained element of conservatism in the peer committees, is perhaps tending to suppress an adequate degree of risk-taking in this program, a question that Council and its senior committees are now considering.

- Any researcher may apply for and hold **only one** Individual or Team Operating Grant. Thus, failure to obtain an operating grant means no second chance for this type of NSERC support during that year.

- Operating Grants therefore represent an investment in the research of highly intelligent and motivated people working on the frontiers of science and engineering. Given the resource psyche of this nation, and a willingness to spend billions of dollars each year on frontier wildcat drilling, it is perhaps appropriate to draw a parallel between frontier drilling and frontier science. Both are driven by the need for discovery, both are essential for future economic growth, both depend largely upon the intellect and intuition of highly trained individuals, and both are heavily funded from federal government coffers. In the recent past, however, financial incentives for frontier drilling have been far easier to come by than the much more modest amounts required for investment in today's and tomorrow's intellectual capital through the programs of NSERC.

- Finally, Operating Grants represent a major investment in both research and research training. No other investment in research and development has this same double-barrelled effect. Through the ongoing support of a system of free enquiry, NSERC provides an essential training ground for the graduate students who will be our future leaders in research and development as well as in the application of new technology. The importance of this unique and essential role of university research is increasingly being recognized in Canada and abroad as evidenced by the Introduction to this report. Strong endorsements are emanating from an ever-widening population of business and government leaders; unfortunately, more so in the United States than in Canada. But those who analyse the increasing dependence of our economy on sophisticated new technologies appreciate the critical role to be played by our universities; a role involving frontier research and the development of new highly-skilled research talent. Unless the university research community is adequately funded to pursue this dual mandate, the whole fabric of the national R&D effort will ultimately disintegrate. NSERC's program of Operating Grants is the most effective mechanism to ensure that this does not happen.

More will be said later about the growing importance and required funding of Operating Grants. The balance of this Chapter focusses on the allocation of the funding over the past five years and Council's efforts to ensure an effective operation of the peer review system.

Operating Grants: Overall Funding

As illustrated in Figures 3 and 4 of this report (page 8), the budgets for the Discipline Research Grants, while experiencing a real growth equal to 17% of NSERC's new funding, have actually decreased as a percentage of Council's total program expenditures. While this may appear inconsistent with the foregoing commentary, it is, in fact, consistent with the overall logic of the first Five-Year Plan. Faced with the critical need to train research manpower for the future of all national R&D efforts, and with the serious state of obsolescence of research equipment, the Council decided that corrective actions had to be concentrated on those areas, if any effective rebuilding of the overall research environment was to be realized. Accordingly, the plan called for real growth in Operating Grants, but at a far more modest level in percentage terms than that proposed for research manpower training and research equipment which had suffered more severely during the previous decade. The first Five-Year Plan stressed, however, that growth in these other programs would not be funded at the expense of Operating Grants, and Council has kept that promise.

As previously mentioned, Council received less than the most modest level of overall funding projected by the first Five-Year Plan; this made the allocation of budgets all the more difficult. Figure 15 shows, however, that the program of Operating Grants(1), expressed as a percentage of total program expenditures over the five-year period, exceeded the level envisaged in 1979 (for a larger overall budget). Table 13 tracks the Operating Grants expenditures in relation to the Council's total program expenditures over the past decade (in constant 1984-85 dollars). The effort over the past five years has been to restore a more reasonable and healthier balance among the Council's heavily interdependent activities. Sections II and III of this report reassess that balance now that corrective measures have been taken, and call for a renewed emphasis on Operating Grants over the balance of this decade.

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(1) excluding the research grants to University Research Fellows

Figure 15

Operating Grants as a Percent of Total Program Expenditures

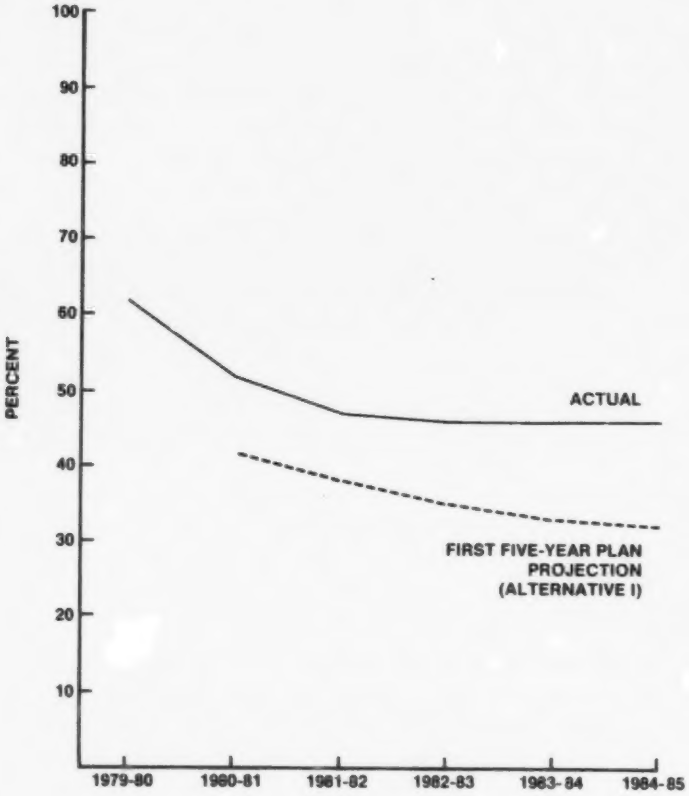

Table 13

Operating Grant Expenditures as percent of Total Program 1974-1984
(millions of constant 1984-85 dollars)

							First Five-Year Plan				
							(1)	(2)	(3)	(4)	(5)
	74-75	75-76	76-77	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85
Total Program Expenditures	159.3	163.9	163.0	172.0	181.3	185.1	222.5	247.0	265.7	288.4	300.6
Operating Grant Expenditures (1)	101.7	106.3	110.1	114.3	118.3	114.4	115.1	117.0	122.9	131.5	137.8
Operating Grants as a % of Total	63.8	64.9	67.5	66.5	65.3	61.8	51.7	47.4	46.3	45.6	45.8

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(1) Includes Individual, Team, Project and Coop grants

Over the course of the first Five-Year Plan, the cumulative growth (in constant 1984-85 dollars) of Operating Grant expenditures (excluding research grants to University Research Fellows) was $52.3 million. During that period, a total of 2136 researchers applied to the Council for the first time and, consistent with Council's policy of providing new applicants with an opportunity to demonstrate their research capability, 1598 new awards were made, involving a total of $54.3 million, **$2 million more than the total new funds allocated to the operating grants program.** Table 14 presents the history of new applicants, their success rates in the competitions and the average awards made.

Table 14

First-Time Applicants for Operating Grants

		First Five-Year Plan				
	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Number of New Applicants	361	361	410	411	502	452
Number of Awards	271	281	305	320	370	322
Success Rate (%)	75	78	74	78	74	71
Funding Rate (%)	43	41	37	44	47	46
Average Grant (constant 1984-85 dollars)	$12,045	$10,875	$10,887	$11,727	$13,132	$14,797

Given that its total allocation of new funding for Operating Grants was more than utilized by new applicants, NSERC had to find other mechanisms to promote and reward truly outstanding performance by established researchers. The funds to do this had to be found from within the program and, during the course of the five-year period, a total of $23 million (constant 1984-85 dollars) was freed up through reduced grants or attrition of researchers in the system. This $23 million was then allocated as follows:

- $2 million to new researchers (bringing the total to $54.3 million),
- $15 million to grant increases for selected researchers, and
- $6 million as special adjustments to selected discipine groups.

This demonstrates that the established research force of over 6000 now supported by Council, saw only very modest overall gains in their average operating grant during the past five years. In fact, the average Individual Operating Grant in 1984-85 was $21,857. The comparable award in 1979-80 was $20,017 and that of 1969-70 was $24,875 (all in constant 1984-85 dollars). Modest growth has been achieved over the five years, but the average award is still 14% less in constant dollars than it was fifteen years ago.

In summary, the priority given to new applicants has resulted in only modest growth in operating funds for established researchers. They have, of course, benefitted directly from injections of new equipment, increased infrastructure support and increased numbers of graduate students. While this assistance was badly needed, it brought with it concomitant costs for services and supplies, further increasing the demands on relatively static research grants. The consequences of this are discussed later.

Operating Grants: Allocation by Discipline

NSERC manages a granting system that is largely responsive in nature. Within the Operating Grants program therefore, budget allocations to the various peer review committees are premised largely upon the number of applications received and the level of previous grants held by the applicants. Growth in the funding of a discipline occurs through increased numbers of professors, increased applications to NSERC and, therefore, an increased allocation of the total available budget. While this procedure has its good points, it does not always reflect adequately the changing nature of research in some areas and the special needs of researchers in relatively new or rapidly expanding areas, e.g. artificial intelligence and biotechnology.

Therefore, the Council embarked upon what has developed into an ongoing analysis of budget allocations on a discipline by discipline basis. Where are the special needs? Where is the focus of new challenges? Where is the most productive work being pursued? In many ways this has been both a thankless and frustrating endeavour because of the multitude of intangibles involved. However, some special areas of need have been identified and modest adjustments made to committee budgets. Table 15 presents the distribution of Operating Grant funds among disciplines over a six-year period. A more detailed breakdown is given in Appendix III.

Table 15

Percentage Distribution of Operating Grant Expenditures (Number of Grants)[1]

Discipline	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Biology	24.9 (22.7)	25.2 (22.5)	25.3 (22.5)	25.2 (22.2)	24.6 (21.9)	25.2 (22.5)
Psychology	4.6 (5.0)	4.7 (5.3)	4.8 (5.7)	4.8 (5.9)	4.7 (6.0)	4.7 (5.9)
Chemistry	13.2 (9.8)	12.8 (9.6)	12.9 (9.6)	12.8 (9.5)	12.3 (8.7)	11.8 (8.3)
Physics	17.3 (12.3)	17.1 (12.2)	17.0 (11.8)	17.2 (11.7)	17.1 (11.0)	16.1 (10.8)
Engineering	22.5 (23.8)	22.6 (24.2)	22.5 (24.2)	22.1 (23.7)	23.4 (24.9)	24.2 (25.7)
Earth Sciences	8.3 (8.6)	8.3 (8.5)	8.1 (8.2)	8.2 (8.6)	7.9 (8.4)	7.7 (8.0)
Comp./Info. Sci.	3.7 (4.5)	3.8 (4.7)	3.8 (4.9)	3.9 (5.0)	4.4 (5.5)	4.5 (5.6)
Math./Stats.	5.3 (13.1)	5.3 (12.8)	5.2 (12.7)	5.2 (12.7)	5.1 (13.0)	5.3 (12.6)
Interdisciplinary	0.2 (0.2)	0.2 (0.2)	0.4 (0.4)	0.6 (0.7)	0.5 (0.6)	0.5 (0.6)
Totals:						
Millions of constant 1984-85 dollars	113.3	113.5	114.6	121.2	130.6	137.6
Number of grants	5,401	5,433	5,525	5,690	5,914	6,009

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(1) Includes Individual, Team and Project grants

Finally, Table 16 compares the number of grantees and the average grant in 1979-80 and 1984-85 among the disciplines.

Table 16

Comparison of Average Individual Operating Grants
(constant 1984-85 dollars)

	1979-80		1984-85		% Increase Over Six Years	
Discipline	Number	Av. Gt.	Number	Av. Gt.	Number	Av. Gt.
Biology	1211	22,991	1326	25,641	9	12
Psychology	270	19,107	342	18,371	27	-4
Chemistry	520	28,146	491	32,799	-6	17
Physics	597	22,873	564	25,238	-6	10
Engineering	1265	19,592	1516	21,408	20	9
Earth Sciences	459	20,192	480	21,987	5	9
Comp./Info. Sci.	239	17,401	336	18,264	41	5
Math./Stats.	708	8,427	753	9,607	6	14
Interdisciplinary	9	19,968	32	20,240	356	1
NSERC Average	5278	20,017	5840	21,857	11	9

Operating Grants: The Selectivity Push

NSERC has been pressing its peer review committees to be increasingly selective so as to be in a position to fund more adequately those individuals doing the most productive work. For this reason, NSERC felt compelled to push its grant selection committees to even greater levels of selectivity than had been the case in the past. Council was well aware of the consequences of this policy on the research effort in some departments, and on the careers of the individuals concerned, but felt that this was necessary to obtain the maximum benefit from the available resources and to enable young researchers to develop quickly. Productivity and excellence of past research endeavour, coupled with the potential for future advances, remain the prime selection criteria.

Accordingly, the Council advised the selection committees in 1982-83 that **new** funding added to their normal allocations would be in the form of merit supplements would be available only to boost the research award of selected grantees. In addition, as an added means of forcing selection committees to be more selective, the Council required that they increase the award of a meritorious grantee using their fixed overall allocation before being given access to the merit supplement fund for that applicant. For example, in 1983-84, the Engineering committees which had had their overall budget increased by 10%, had to increase the grant of a selected applicant by 20% before they could tap the merit supplement fund to award an even larger grant to that individual. The Cell Biology committee, which had had no special increase in its base budget had to provide a 6% increase to the grant of a selected applicant before the merit fund was accessible.

This policy therefore enforced a greater degree of selectivity; some existing grants had to be cut to find real increases for productive researchers and only then could the new merit supplement fund be applied to those same researchers. Table 17 shows the success rates achieved by established researchers applying for a renewal of their Individual Operating Grants during this period. It shows that in 1984-85, about 10% of the established researchers did not obtain a renewal of their grant. Given the consequences of this on both a research and academic career, these decisions are not taken lightly. It is, therefore, not too surprising that initially the reaction of the committees was mixed; some spread the new funding as thinly as the system would permit, others focussed the new resources on a relatively small number of researchers. In the second year of the process, the Council tightened up the procedures to ensure a reasonable degree of selectivity.

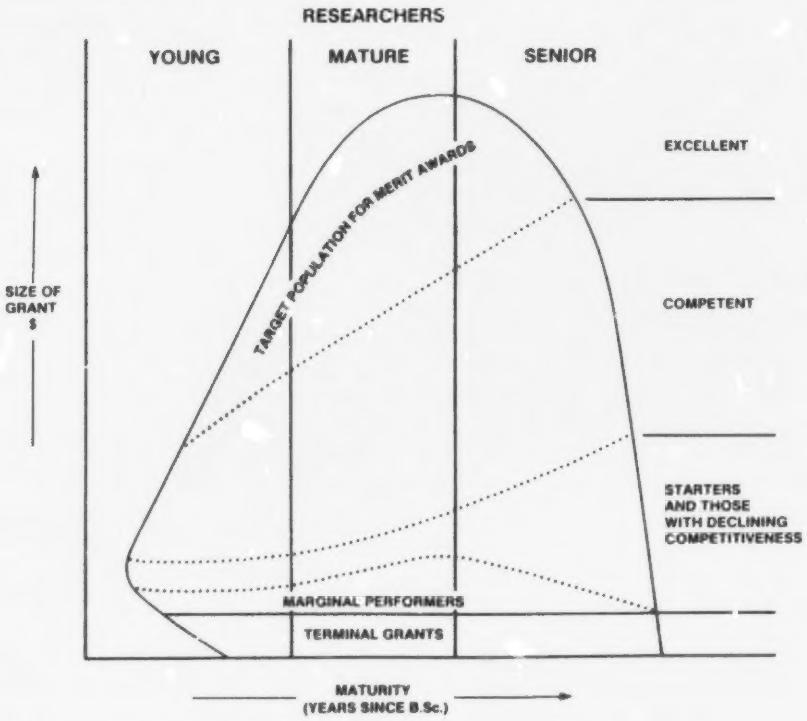
Having completed a three-year cycle of this process in 1984-85, the Council is generally satisfied with the results. While a few departments of some universities have been hard hit, there does not appear to have been an especially serious negative impact on small universities as was initially feared. (In the 1984-85 competition, the Mathematics committee received 195 applications for grant renewals and 36 of those were rejected. All 36 had previously held awards of less than $6000/year but only 6 of the 36 came from "small"(1) universities).

Furthermore, there was some concern that the new funds would be concentrated largely on the established "stars" of each discipline. This has not happened. As the Council hoped, bright young researchers and very competent professors who entered the system during the difficult decade of the 70s have also benefitted. The target population for these "merit supplements" as graphically presented by Figure 16 has been reached.

A final word on selectivity is required. First, NSERC's Individual Operating Grants are awards to individuals **and only one grant can be held at any one time;** they are not project awards such as those made by the National Science Foundation in the United States or to some extent, by the Medical Research Council in Canada where multiple applications are possible. Therefore, a comparison of success rates with other agencies can be very misleading; a more meaningful comparison of NSERC's success rates would be the project-oriented Strategic Grants with the programs of the other councils. The rejection rates for established researchers in the Operating Grants Program as shown by Table 17 are very sobering, not only because of the impact on the individual concerned, but also on the graduate students formerly supported through those grants.

Figure 16

Target Areas for Merit Awards


RESEARCHERS
YOUNG
MATURE
SENIOR
TARGET POPULATION FOR MERIT AWARDS
EXCELLENT
COMPETENT
STARTERS AND THOSE WITH DECLINING COMPETITIVENESS
SIZE OF GRANT $
MARGINAL PERFORMERS
TERMINAL GRANTS
MATURITY (YEARS SINCE B.Sc.)

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(1) Defined as having 100 or fewer individuals applying to NSERC each year.

Table 17

Percent Success Rate (and Number of Awards) for Grantees Competing for a Renewal of Individual Operating Grants

Grant Selection Committee	Competition Year							
	1981		1982		1983		1984	
Animal Biology	87.4	(90)	94.3	(116)	96.7	(88)	94.7	(107)
Cell Biology	93.9	(92)	94.1	(127)	86.2	(106)	87.9	(87)
Plant Biology	88.7	(63)	91.7	(66)	92.7	(76)	88.9	(72)
Population Biology	92.4	(85)	96.5	(109)	91.7	(133)	92.6	(112)
Psychology	92.5	(74)	97.7	(84)	100.0	(70)	89.7	(87)
Chemistry	96.5	(248)	96.8	(239)	91.0	(242)	87.9	(174)
Physics	97.6	(161)	97.8	(136)	92.3	(156)	93.0	(133)
Nuclear Science	97.5	(39)	100.0	(31)	97.0	(32)	97.2	(35)
High Energy Physics	--	--	100.0	(1)	100.0	(1)	100.0	(1)
Space/Astronomy	98.0	(48)	97.6	(41)	100.0	(56)	93.5	(43)
Chem./Met. Eng.	95.3	(101)	95.4	(62)	98.4	(127)	87.7	(107)
Civil Eng.	100.0	(73)	94.8	(91)	96.4	(106)	89.4	(76)
Electrical Eng.	96.4	(161)	98.6	(144)	98.6	(212)	89.8	(123)
Mechanical Eng.	97.6	(82)	94.1	(96)	95.9	(116)	93.5	(72)
Industrial Eng.	76.0	(19)	96.6	(28)	97.6	(41)	96.2	(25)
Earth Sciences	93.5	(216)	98.7	(231)	95.7	(176)	88.4	(175)
Comput./Info. Sci.	98.0	(148)	95.8	(160)	97.1	(168)	91.4	(160)
Mathematics	95.0	(171)	96.2	(152)	97.5	(153)	82.7	(148)
Statistics	100.0	(7)	94.9	(56)	90.6	(48)	95.8	(46)
Interdisciplinary	60.0	(3)	100.0	(8)	75.0	(6)	100.0	(6)
NSERC	94.8	(1881)	96.3	(1978)	94.8	(2113)	90.0	(1789)

It must also be remembered that applicants for NSERC awards are not ordinary individuals. Rather they have already passed a long series of hurdles to achieve their present positions; first to get into university, then to be accepted into graduate school (many with scholarships), then to successfully pursue postdoctoral study and, finally, to compete successfully for limited academic positions. At that point they must compete again for NSERC awards. Given this background there have been a few suggestions that minimum NSERC awards should come automatically with a faculty position as is the case in Japan. NSERC does not agree; the competitive aspect of the Council's programs promotes excellence and hence must be maintained.

Operating Grants: The Focus of Research

Given the freedom and flexibility that Operating Grants give to the award holder, it is frequently assumed that all of these grants end up in support of fundamental or basic research. Such is not the case; Operating Grants support a broad range of activity from the very pure to the very applied. Many university researchers need no "direction" from government or industrial sources to select industrially relevant areas of research. They do it because of the challenge it presents and they are frequently pursuing it well in advance of its "discovery" by the research planners.

In 1980-81 NSERC asked applicants to identify the "primary area of application" of their proposed research effort. Included in the twelve areas is the category of "General Advancement of Knowledge" which comprises fundamental research pursued mainly for the sake of new knowledge, although some areas of possible application may be envisaged. Table 18 presents a five-year history of responses. The main conclusions that can be drawn are that:

- There has been a steady reduction in the number of research programs focussed primarily on "General Advancement of Knowledge" (51.3% in 1980-81 to 45.3% in 1984-85).

- There has also been a gradual percentage reduction in the awards where primary resources are the main target, e.g. fisheries, forestry, energy and "the solid earth".

- the largest percentage growths have been in research areas with application in:

    a) "Industrial Productivity and Development"
    (10% of all research awards and 9.9% of funds in 1984-85);
    b) "Health", e.g. biomedical engineering and biotechnology; and,
    c) "Social Development and Service", e.g. computer-aided learning.

Table 18

Percentage Distribution of Operating Grant Funds (and Number of Grants) by "Area of Application" (1)

	First Five-Year Plan				
	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Agriculture, Fisheries, Forestry, Food	8.9 (8.2)	8.8 (8.3)	8.8 (8.3)	8.2 (7.7)	8.1 (7.7)
Energy	6.2 (6.1)	6.7 (6.5)	6.9 (6.5)	6.4 (5.8)	6.2 (5.7)
Environment: Management and Restoration	3.3 (3.3)	3.8 (3.8)	4.2 (4.1)	4.3 (4.5)	4.2 (4.5)
The Solid Earth: Hydrosphere and Atmosphere	5.9 (5.7)	5.4 (5.2)	5.0 (4.8)	4.7 (4.6)	4.7 (4.6)
Health	4.4 (4.3)	4.7 (4.7)	5.4 (5.5)	5.8 (5.9)	6.1 (6.2)
Construction: Urban and Rural Planning	4.0 (4.0)	4.0 (4.1)	4.4 (4.5)	4.6 (4.6)	4.6 (4.6)
Social Development and and Service	1.7 (2.3)	1.9 (2.5)	2.1 (2.9)	2.6 (3.7)	2.8 (4.1)
Industrial Productivity and Development	8.9 (7.9)	8.2 (8.4)	8.6 (8.8)	9.5 (9.6)	9.9 (10.0)
Transportation and Telecommunication	2.8 (3.0)	2.8 (3.1)	3.0 (3.1)	3.1 (3.3)	3.3 (3.5)
Space and Aeronomy	1.1 (0.6)	1.3 (0.7)	1.2 (0.8)	1.1 (0.7)	1.0 (0.6)
Northern Development	0.6 (0.6)	0.5 (0.5)	0.6 (0.6)	0.7 (0.7)	0.7 (0.6)
General Advancement of Knowledge	51.1 (51.3)	49.8 (49.6)	49.2 (49.3)	47.4 (47.4)	46.0 (45.3)
Not Reported	2.1 (2.7)	2.1 (2.5)	0.8 (0.7)	1.6 (1.5)	2.2 (2.6)
Total:					
- millions of constant 1984-85 dollars	110.2	112.2	117.2	124.5	131.7
- number of grants	5414	5530	5662	5868	5921

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(1) Includes Individual, Team, Co-op Grants

In some ways the data presented in Table 18 are disturbing, e.g. why has there been a decrease of 10% in the number of researchers focussing their research on "The Solid Earth: Hydrosphere and Atmosphere"? On the other hand, the data dispel the theory that university researchers have to be directed to work on programs relevant to currently identified national needs; in 1984-85, the year that NSERC's Strategic Grants program was inundated with 152 applications in the new area of "Industrial Materials and Processes", there were already $13 million of Operating Grants aimed at Industrial Productivity and Development. Clearly, industrial research challenges are not lost on the academic research community.

Summary

Much more can be said about Discipline Research Grants and the essential role they play in the total national research and development effort. Sections II and III of the report will use this review of Operating Grants to further develop the role of this program in the next Five-Year Plan. In Council's view, the past five-year period has been a real test of the program itself, of the peer review system and of the research community. Those who depend largely upon Operating Grants for their work have seen substantial new funding flow to NSERC, but very little appear through the Operating Grants system. At the same time they have experienced a constantly increasing demand on their grants, in part for services the universities themselves used to provide free of charge.

While there is no doubt that some good researchers and quality research have not been supported at an appropriate level because of NSERC's priority on equipment and manpower training initiatives and on even greater selectivity in the awarding of Operating Grants, NSERC is convinced that the overall program is in much better shape now than it was five years ago. The peer review committees now meet annually for discussions of policy and for consultation with NSERC staff; many committees now have members drawn from outside the academic community with a significant number from industry; and in 1983-84 there were some 260 visits to universities by committee members to meet the researchers first-hand compared to 109 such visits in 1979-80. Engineering committees in the meantime have accepted modified review criteria that place greater emphasis on indicators of success other than research publications. Equally encouraging is the fact that a number of the science-based selection committees have voluntarily encompassed those "engineering criteria" into their own peer review process. And finally, the whole peer review process itself received strong endorsement in the August 1984 report of the Task Force on Federal Policies and Programs for Technology Development:

> "Because of the expertise of these granting agencies and because most of their decisions are made with the benefit to extensive peer review, we believe the vast bulk of these dollars are intelligently spent. NSERC is especially effective. Its funding decisions are made not by bureaucrats, but by fellow-members of the scientific community. When it considers the funding

> of research programs that would have an impact on a particular industry or erd user, those interested parties are included in NSERC's decision-making process.(1)

During the course of 1985, a detailed evaluation of the program of Operating Grants will be undertaken by a team of external consultants. In view of the magnitude and complexity of the task, the study will take up to two years to complete. There is no doubt in the Council's mind, however, that the consultants will find the Operating Grants program an extremely efficient and effective mechanism to support a major share of the long-term research effort so essential to this nation and so well-placed within the universities where research training can be provided in parallel. The funding provided for the second Five-Year Plan will determine the extent to which we can exploit this unique efficient vehicle.

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(1) Page 20, paragraph 3 of the Task Force Report.

CHAPTER 5

TARGETED RESEARCH: REINFORCING THE BRIDGE TO THE USER COMMUNITY

The previous chapter has focussed on the need for a healthy level of free enquiry within the universities. However, NSERC recognized from the time of its creation that university-based research could not thrive in isolation. There must be an outlet for the research results, and the user community must be given an opportunity to provide input. The following extracts from the 1979 Five-Year Plan reflect Council's determination to bridge the gap between these two communities:

> "There is obviously much to be done to improve the university-industry interface. NSERC's existing programs will be improved and expanded, but new initiatives are required. Some of these will focus, at least initially, on the engineering schools where unique opportunities and challenges exist for increased cooperation on specific problems. It is hoped that such cooperation will lead to an increase in the production of doctors of engineering better prepared for industrial research. Other NSERC activities will relate to broader programs aimed at developing interactions at the university-industry interface throughout graduate studies and sustaining those exchanges through to postdoctoral programs. The expanded use of workshops to plan, monitor and audit Council programs will provide increased opportunities for industry input as will greater industrial participation on Grant Selection Committees."

....

> "The value of a year's experience in industrial research laboratories should be given increased importance during evaluations made by the universities (and by NSERC's grant selection committees). As matters now stand the university researcher who takes such an initiative to broaden his training and perspective is usually penalized by the "system" upon his return."

....

> "The size of the challenge should not be underestimated nor should an overnight solution be expected. However, NSERC is strongly of the view that the current situation can be improved and is determined to pursue programs which will work towards that end."

While the challenge identified in the first Five-Year Plan has by no means been fully resolved, there have been very clear signs of progress, some of them as a result of the new and expanded programs of NSERC. This Chapter reviews Council's achievements through initiatives designed specifically or partially to "reinforce" that essential bridge between the university research effort and the user community.

The word "reinforce" has been chosen deliberately to reflect the fact that university-industry interaction existed long before the specific targeted programs and would exist today without those programs. The frequent use of the expression "two solitudes" to describe university and industry researchers is to make a point, to present a challenge; unfortunately it is seized upon by some to overstate the case or to argue that "never the twain shall meet". It is therefore important at the outset to touch on what is happening at the university-industry interface through the program of Operating Grants before dealing with the specific targeted initiatives.

It should not be surprising, given the distribution of effort documented in Table 18 (page 53), that there is much more routine interaction between industry and university researchers than first meets the eye. The fact that it is done quietly through individual initiative, rather than through "directed" programs, does not make it any less beneficial. On the contrary, the self-motivation behind the effort probably bodes well for the effectiveness of the linkages developed and the technology (and people) transferred.

The first evaluation of NSERC programs by external consultants focussed on two university-industry initiatives: the PRAI (Project Research Applicable in Industry) Grants program and the Senior Industrial Fellowships program. The conclusions reached on these two activities are recorded in Appendix IV, but the analysis carried out also resulted in the following observations with regard to the Operating Grants program:(1)

- 28% of the researchers have actually transferred research results to an industrial firm during the past five years;
- 54% of the researchers expect to transfer the results of some of their present research to a firm within the next five years;
- 26% of the researchers expect to transfer the results of that research after at least five more years of development;
- the role of the NSERC Operating Grants in the industry-oriented R&D effort at universities is vital: 72% of the researchers who expect to transfer technology to a firm within the next five years cite their Operating Grants as a major source of funding for that research. For those results to be transferred over the longer term, the dependence on the NSERC Operating Grants as a major source of funding increases to 83%.

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(1) based on a sample of 208 holders of Operating Grants

The following review of targeted programs must therefore be seen in this global context; these programs reinforce and facilitate what is already happening to an encouraging extent. Furthermore, a very significant percentage of university-based research must be aimed at the general advancement of knowledge rather than at the current perception of industrial needs. The universities are the natural habitat for this essential longer-term 'discovery research" and that aspect of research must be protected and expanded at the same time as the bridges between universities and industries are strengthened. We must not allow the pendulum to swing too far. The countries that have permitted that to happen are now scrambling to return to a more sustaining mix of research effort.

With that as background, progress in the Strategic Grants and University-Industry programs will now be reviewed.

Strategic Grants

This program had its beginnings under the National Research Council in 1977-78, just prior to the creation of NSERC. In 1977-78, the first year of the Strategic Grants Program, the budget was \$2.3 million and three areas of research were eligible for support: Energy, Environmental Toxicology and Oceans. By 1984-85 the budget had grown to \$32.3 million with eight targeted areas of research. This program now represents NSERC's major effort in areas of research identified by the Council rather than by the researchers. Having said that, however, a significant degree of research freedom is maintained. Under the "Open" research category, proposals in any field of endeavour may be submitted; under the designated areas such as "Energy", where only the broad field is circumscribed, proposals are welcomed in any activity that is relevant to energy production, transportation, or use. While targeting does exist, and relevance of the research projects must be established, NSERC and its Strategic Grants Committee maintain a fairly loose hand on the reins.

A five-year record of this program is summarized in Tables 19 and 20 and a complete record back to 1977-78 is presented in Figure 17. Significant funding growth took place prior to the first Five-Year Plan and that momentum has generally been maintained throughout as shown by Table 19. Table 19 also shows that the total funding for Strategic Grants, presented as a percentage of the total NSERC budget, has fallen below that suggested by the first Five-Year Plan. Table 20 presents overall program data for new applications and awards. Appendix IV breaks this information down into individual areas, although not too much importance should be placed on these individual trends; there has been a significant movement of applications and awards from one area to another during the five-year period as new areas of support were identified. For example, ongoing research programs were transferred from "Energy" to "Biotechnology" in 1982-83 and from both "Energy" and "Open" to "Industrial Materials and Processes" in 1984-85.

Table 19

Funding Levels for Stratetic Grants
(thousands of constant 1984-85 dollars)

Area	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85*
Energy	5,826	8,492	8,202	8,281	8,215	4,854
Environmental Toxicology	4,147	4,844	3,783	3,772	3,224	2,742
Oceans	2,530	3,332	3,373	3,636	2,921	2,959
Communications and Computers	1,510	2,945	3,513	3,949	3,649	5,299
Food-Agriculture	2,727	3,729	5,029	3,770	4,529	4,867
Open Area	---	1,548	3,150	3,104	3,626	2,896
Biotechnology	---	---	---	2,766	3,508	3,566
Industrial Materials and Processes	---	---	---	---	---	5,071
Total Expenditures:						
- constant dollars	16,740	24,890	27,050	29,278	29,672	32,254
- current dollars	10,707	17,780	21,565	26,305	28,258	32,254
Awards as a Percentage of NSERC's Program Budget:						
Actual	9.0	11.2	10.9	11.0	10.3	10.7
Projected: First Five-Year Plan (Alternative I)	---	10.4	10.8	11.3	10.1	12.3

---

* Major reductions in some areas are due in part to the transfer of several on-going projects to the new area of "Industrial Materials and Processes".

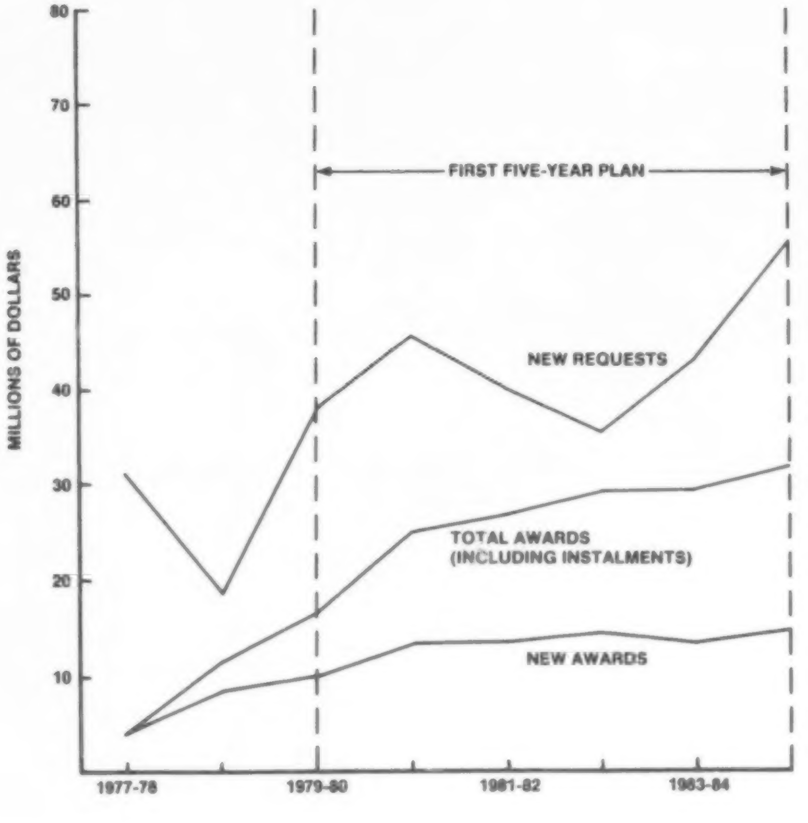
Table 20

Strategic Grants: Applications and Awards (New Applications Only)

	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Funding						
(thousands of constant 1984-85 dollars)						
Requests	37,865	46,183	40,112	36,349	43,067	56,496
Awards	10,223	12,731	13,038	13,752	13,186	14,431
Funding Rate (%)	27	28	33	38	31	26
Number of Applications						
Requests	622	631	549	578	648	812
Awards	188	212	203	239	224	250
Success Rate (%)	30	34	37	41	35	31
Number of Awards by Type						
Individual	70	79	60	69	68	73
Group	82	93	98	109	106	111
Equipment	36	40	45	61	50	64
Conference	--	--	--	--	--	2

FIGURE 17

Strategic Grants - Funds Requested and Awarded
(millions of constant 1984-85 dollars)



Overall, there has been an increasing interest in this program over the years and the earlier concerns of some segments of the community regarding "directed research" seem to have all but disappeared. A breakdown of awards by discipline for 1984-85 (Table 21) shows that the engineering, chemistry and biology communities have been the most active participants in the program. Given the thrust of a number of the Strategic Grant areas, and the fact that a test for relevance must be met, it is not surprising that research teams led by researchers from engineering departments accounted for 30% of the new awards made in the last competition.

Table 21

Strategic Grants by Discipline in 1984-85
(New Awards + Instalments)*

Discipline	Awards		Level of Support	
	Number	Percent	$000	Percent
Biology	164	(30.0)	8,074	(25.0)
Psychology	3	(0.5)	198	(0.6)
Chemistry	62	(11.4)	3,388	(10.5)
Physics	32	(5.9)	1,938	(6.0)
Engineering	162	(29.7)	10,518	(32.7)
Earth Sciences	35	(6.4)	2,418	(7.5)
Com/Info. Sci.	21	(3.8)	2,076	(6.8)
Mathematics and Math./Stats.	1	(0.2)	45	(0.1)
Interdisciplinary	7	(1.3)	340	(1.1)
Other**	59	(10.8)	3,259	(10.1)
Total	546	(100.0)	32,254	(100.0)

---

* Discipline of principal applicant only. Group awards may well be interciplinary efforts.

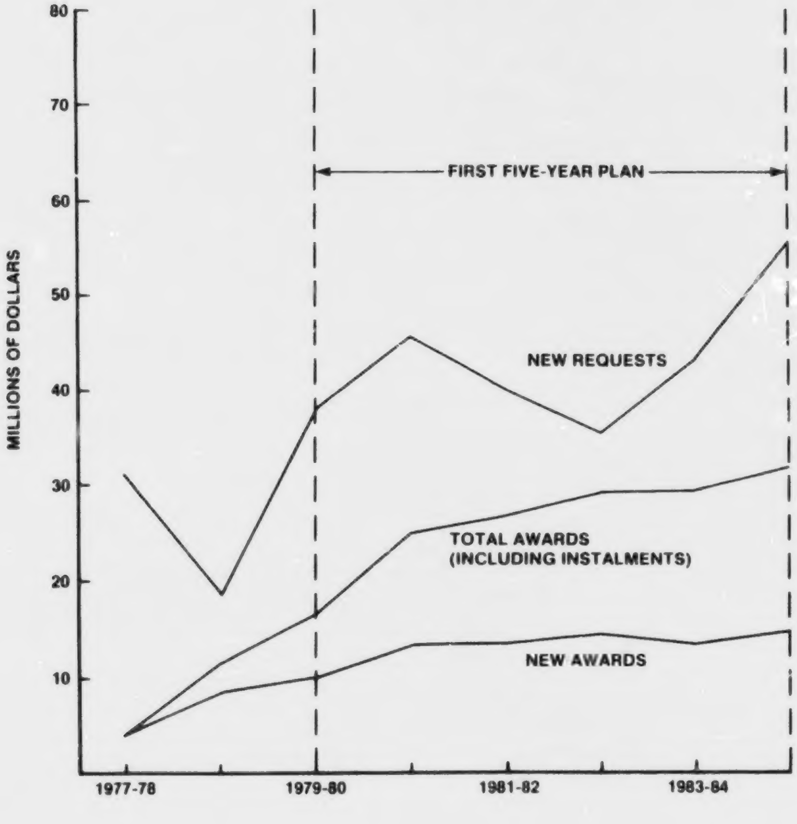
** Included here are those principal applicants who do not hold operating grants.

Looking back at the early resistance to the program, it is of interest to note that, as might be expected, the research leaders in the Operating Grants program have also emerged as the leaders in this targeted initiative. Appendix IV contains an analysis of this; on average, Strategic Grant holders in 1984-85 had Operating Grants more than 50% larger than the average Operating Grant.

The competition for Strategic Grants has become increasingly difficult because applications have increased faster than available budgets and because selection panels have therefore had to become increasingly selective. The panels, as is the case for Operating Grants, look for an excellent research record and research proposal. In addition, however, the Strategic Grants panels must assess the relevance of the research proposal to national needs - a difficult and subjective task. To be successful, a very high score is required on **each** of these three selection criteria. In many cases, lack of success of applications from excellent researchers can be traced to a poorly defined project lacking adequate milestones or benchmarks of progress. Contrary to the Operating Grants program, this is a program of project funding with "deliverables" expected at the end, a distinction that some researchers still fail to grasp.

FIGURE 17

Strategic Grants - Funds Requested and Awarded
(millions of constant 1984-85 dollars)



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The greatest single cause for failure, however, has been the criterion of relevance. In many ways relevance, like beauty, is in the eye of the beholder and is further complicated by the question of timing. A research product developed within 10 years may be very relevant, but if production is many decades away there is a natural tendency to see the effort as being more appropriate to the Operating Grants program. The Council must develop its definition of relevance as accurately as possible; thereafter the decisions rest largely on the collective wisdom of the peer system. There is no better way of dealing with this issue.

Given the fact that the program is now in its eighth year, it is clearly appropriate to ask about research successes. Appendix IV lists some of the achievements that have been identified by the selection panels. Many other grants have been successful or have found degrees of success that may lead to future research achievements. Even those that have failed have produced new knowledge; what to do and what not to do. The earlier parallel drawn between frontier drilling and frontier research applies here as well; even failure brings more geological or fundamental knowledge so that your next effort will have a greater potential for success.

A last element of success, however, relates to research training. Strategic Grants have boosted the proportion of university research that appeals to students motivated by real needs and relevant topics. In fact, the existence of Strategic Grants, and the exciting research that they sponsor, may well have contributed to the development of new areas of research in Operating Grants. All in all, there is now a much better mix of research endeavour to attract a growing number of students to Canadian graduate schools.

Finally, with regard to university-industry interaction, have Strategic Grants really promoted that sought-after reinforcement of the bridge to the user community? The answer is an emphatic yes, although in many respects it is difficult to quantify and much remains to be done by Council, especially in the area of dissemination of research results. While the program was not originally conceived as a specific mechanism for university-industry cooperation, the following two actions, in particular, have promoted that end result:

- The application form itself pushes the researcher to consult with the user community by requiring responses to the following:

  (a) What will this project contribute to the advancement of knowledge in the strategic area? Discuss the potential socio-economic benefits for Canada and the time frame for the application of the results by potential users.

  (b) Identify users in industry and government who could benefit from this project.

(c) Describe contacts already made with potential users.

(d) Discuss plans for promoting the project results to the user sector. If support for workshops or seminars is requested provide details of the plans for this activity.

- These requirements promote university-industry interaction even before the submission of the application. The specific initiatives described in the second part of this chapter will serve to reinforce this action.

- The Strategic Grant Selection Panels include a significant number of specialists from the user communities (industry and government). Obviously the mix varies depending upon the subject matter (e.g. environmental toxicology vs. communications and computers), the maturity of the industry (e.g. biotechnology vs. energy), and the availability of key researchers. However, as shown in Table 22, the mix of the three major research communities on the Panels is significant. In addition, the involvement of other industrial specialists on visits to universities to review applications gives those specialists an excellent insight into what is being done in university laboratories and who is doing it. One industrial-based member of the selection panel for Communications and Computers has described that experience as the best promoter of university-industry collaboration he has ever seen.

Table 22

Membership Distribution of Strategic Grant Selection Panels (1984-85)

	Number (and Percent) of Members from:		
Area	University	Industry	Government
Energy	5 (42)	6 (50)	1 (8)
Environmental Toxicology	5 (45)	1 (9)	5 (45)
Oceans	4 (40)	4 (40)	2 (20)
Communications and Computers	5 (45)	4 (37)	2 (18)
Food and Agriculture	7 (58)	3 (25)	2 (17)
Open	4 (44)	4 (44)	1 (12)
Biotechnology	10 (84)	1 (8)	1 (8)
Industrial Materials and Processes	8 (67)	3 (25)	1 (8)
Total Program	48 (54)	26 (29)	15 (17)

In summary, the Strategic Grants program has emerged as a major and successful component of NSERC's programs and has added an element of project funding which completes the continuum of activities from very fundamental free enquiry to the actual transfer of technology to the user community. Section II of this report will address a few issues that need resolving, but it would appear that the principal cause for concern is the success rate within the program itself; where is the funding going to come from to maintain a reasonable response rate to applications? Certainly, a repeat of the 26% success rate of funding in 1984-85 will "turn off" many good researchers who, having taken the trouble to submit an application are told that the project was "good", but fell below the cut-off point dictated by available funding. Having pursued this program of targeted research, having attracted the interest of industry (1), and having resolved the initial concerns of the community, the Council and the federal government must provide the funding required to ensure a reasonable success rate in future competitions.

Promoting University-Industry Interaction

Project Research Applicable in Industry (PRAI): When the first Five-Year Plan was prepared the only NSERC program that required industry "sponsorship" was the PRAI Grants program. Sponsorship in this case did not necessarily involve financial participation, but at least there had to be a company sufficiently interested in the project to give guidance to the researcher and be capable of ensuring production and marketing of the end product. Council, for its part, would provide funding (now for a period of up to five years) to help move the project through the early stages of product development.

The PRAI Grants program has had a somewhat checkered history. Launched in 1970 by the National Research Council, the program reached an early peak of 80 applications in 1973 and then dropped off to a low of 9 in 1977. Shortly thereafter, NSERC reviewed and streamlined the program and forecast a modest but steady expansion in the first Five-Year Plan. The projected growth and the actual growth of this initiative are presented in Table 23.

The growth in this program obviously did not meet expectations although there was certainly a healthy recovery from the $256,000 expenditure in 1977-78. An evaluation of the program by external consultants was undertaken in 1983 and some of the principal conclusions were the following (a more detailed summary is contained in Appendix IV):

---

(1) In April 1984, questionnaires were mailed out to potential users of research results (in industry and government) asking them to indicate their interest in obtaining summaries of projects funded with NSERC Strategic Grants. The response was very positive; as of March 31, 1985, there were 2,828 subscribers for these publications.

Table 23

Projected and Actual PRAI Expenditures
(thousands of constant 1984-85 dollars)

		First Five-Year Plan				
Expenditures	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Actual Expenditures:	1,588	1,542	2,333	2,618	2,598	2,759*
Projected Expenditures: First Five-Year Plan (Alternative I)	---	3,127	3,440	3,909	4,691	5,473
Number of Awards held:	16	23	36	42	39	41

---

* Includes only awards made under the PRAI Program, does not include any awards made under the expanded University-Industry initiatives.

- "Judged by a variety of criteria, the social and economic impacts are highly positive.

- PRAI results in positive benefits to collaborating firms. These benefits are in the form of: new or altered products; new processes; and cost-saving techniques or innovations. Our case studies indicate that 10 of 22 results of PRAI projects transferred to industry have already been commercialized. Six will likely be marketed in the future, while the remaining six, although of potential benefit to firms will not, in our estimation, result in a commercial product.

- PRAI developed technology is not used by foreign rather than Canadian firms. In no case study did we find the technology being used solely by a foreign firm."

Taking into account the evaluation report, Council was of the view that it must continue to promote cooperative initiatives of this type, that efforts to increase awareness of the program were essential, and that the program should be expanded so as to be more responsive to research needs identified by industry rather than being limited to further development of a research effort originating within the university. In addition, the relatively high degree of success of previously funded projects gave rise to a nagging concern that perhaps the review process itself (and the interest of industry) tended to be too conservative, hence innovative and high-risk ventures were being rejected. In any event, a decision by the federal government in late 1983-84 to increase funding to NSERC for the promotion of a broader range of university-industry initiatives, gave Council the opportunity to restructure its whole approach to the PRAI Grants program.

The University-Industry Program: The special funding referred to above was announced by the government in January 1984. It entailed $2.6 million in 1983-84, $5.9 million in 1984-85 and $8.0 million in 1985-86. Unlike some of the other increases provided to NSERC (see Figure 2, page 6), these funds became part of the ongoing budget of the Council. The only condition imposed by the government was that the industrial partners in any of the joint activities be required to make a real financial contribution to the project.

NSERC seized upon this opportunity to adopt a completely "open-door" policy for joint university-industry endeavours. The respective communities were advised that NSERC would consider any cooperative research and development proposal provided that:

- the industrial partner agreed to make a "significant" financial contribution (real or in kind);

- the research project was suitable for graduate student training; it could not be a short-term problem-solving proposal usually dealt with through contracts; and,

- all proposals were subjected to the Council's normal peer review process.

In the publicity material for this program, several examples of joint activity were suggested:

- Joint research and development (an expanded PRAI Grants program capable of responding to research challenges identified by industry);

- Jointly funded equipment and facilities usable by both university and industry experts;

- Jointly funded research chairs at Canadian universities;

- University-Industry "Affiliations" where a structure is developed to jointly review and propose research programs; and,

- Workshops on specific research problems.

The response between February 1, 1984, and March 31,1985, has been very encouraging. Table 24 presents the mix of applications received and awards made during this period. The regional distribution that has developed to date is given in Table 25.

Table 24

University-Industry Program*
(February 1, 1984 to March 31, 1985)

Program Element	Number of Applications	Number of Awards Approved	Funds Committed (thousands of $) First Year of Awards	Funds Committed (thousands of $) Total Multi-Year Commitment
Cooperative R&D Projects	110	56	5,631	11,817
Shared Equipment and Facilities	17	9	1,200	1,430
Industrial Research Chairs	28	9	1,461	4,207
Workshops and Seminars	15	11	68	68
Affiliations	1	--	--	--
Visiting Fellowships	16	11	72	233
Total	187	96	8,432	17,755

---

* Includes only those awards made under the expanded University-Industry program.
Does not include commitments associated with 41 on-going PRAI projects.
Does not include payments for Senior Industrial Fellows approved in 1983-84.

Table 25

Regional Dimension of University-Industry Program*
(February 1, 1984 to March 31, 1985)

Number (Percent) of Applications	Atlantic	Quebec		Ontario	Prairies	British Columbia	Total
		Francophone	Anglophone				
Requests	17 (7.4)	30 (13.2)	27 (11.8)	93 (40.8)	26 (11.4)	35 (15.4)	228 (100.0)
Awards	13 (9.6)	20 (14.7)	14 (10.3)	53 (38.9)	17 (12.5)	19 (14.0)	136 (100.0)
Pending	3	8	10	20	6	10	57
Committed Funds:							
-thousands of $	1,443	1,806	747	4,317	1,287	1,590	11,190
-percent of total	12.9	16.1	6.7	38.6	11.5	14.2	100.0

---

* Includes PRAI Instalments, plus first year of awards committed under the University-Industry program

Although it is too early to judge the overall effectiveness of this initiative, the reaction from both the industrial and university communities has been very positive. Particularly gratifying is the willingness of industry to invest significantly in research chairs. This is clearly a long-term investment in bright people; one which will pay dividends well beyond the specific interests of the company involved. In one case, for example, a group of 14 companies and associations and two labour unions have joined together to support a research chair in an area of common interest.

Another example of the positive reaction of the communities to the program is the program of Workshops and Seminars: a new initiative launched in an attempt to bridge the gap between the university and user communities. Since the beginning of this program, Council has supported 13 workshops and seminars; 10 of them involved industrial participation. The corporate contribution to these workshops totalled $25,000, 38% of the NSERC investment of $65,000.

The Council is encouraged by results to date and by the strong endorsement of its efforts voiced by the Task Force on Federal Policies and Programs for Technology Development(a): and by the Canadian Manufacturers Association in its recent report "A Future That Works"(b):

> (a)"Of all the Canadian agencies, programs and projects we encountered in the course of our research, NSERC was the most widely praised. We believe it must continue to play an important and expanding role in the development of Canada's scientific potential. The principles under which it operates, and which are to some degree responsible for its success, should be applied more widely: industry participation, peer review and a minimum of bureaucratic complexity."

> (b)"The Natural Sciences and Engineering Research Council (NSERC), the largest single source of funding of university R&D in Canada, has promoted greater co-operation between university researchers and Canadian industry. By using its grant programs with the degree of flexibility needed to forge better links between industry and university, it has also increased the industrial relevancy of university research. Any further encouragement by government agencies should be focused on the NSERC".

University-Industry "Research Training" Initiatives: Although the following programs are part of the Research Manpower programs that were discussed in Chapter 2, a review of university-industry initiatives would be incomplete without at least noting and summarizing their existence. They include the following:

- Undergraduate Student Research Awards to students working in an industrial research environment;
- Industrial Postgraduate Scholarships through which NSERC and the industrial employer jointly fund further graduate training of an employee;
- Industrial Research Fellowships through which NSERC contributes generously over a period of three years to the salary of excellent young PhDs working in Canadian industry;
- Senior Industrial Fellowships and Visiting Industrial Fellowships through which NSERC supports university or industry experts taking a research "sabbatical" within the other community.

The estimated number and total value of these awards for 1984-85 are shown in Table 26.

TABLE 26

University-Industry Research Training Initiatives in 1984-85

Program	Number of Awards	Estimated Total Investment ($000)
Undergraduate Student Research Awards	513	1,366
Industrial Postgraduate Scholarships	26	198
Industrial Research Fellowships	175	2,856
Senior Industrial Fellowships	11	128
Visiting Industrial Fellowships	0	0

Canadian Microelectronics Corporation: The increasing emphasis and reliance on microelectronics has led to a unique mechanism for cooperation by industry, universities and NSERC. Spurred by an offer by Northern Telecom to produce chips from university-based designs of very large scale integrated (VLSI) circuits, the industrial and university communities joined together to produce a proposal for a national network of state-of-the-art design centres at Canadian universities. Part of the proposal called for a coordination and quality control centre at Queen's University to act as a point of single entry to the Northern Telecom fabrication facilities. The proposal was submitted to NSERC in August 1982 and special funding was awarded to NSERC in May of 1983 to permit this plan to proceed. Over the first five-year period, a total of $19.5 million (current dollars) will be awarded.

Broad industry interest and support of this initiative was forthcoming because of the urgent need for more specialists with hands-on experience in designing integrated circuits. Building on this interest, and on the strong cooperative effort evidenced in the development of the proposal, NSERC proposed an implementation process that would promote a continuation of that interaction. Accordingly, the Canadian Microelectronics Corporation (CMC) was established as the delivery mechanism for this national design network. The Corporation's twelve member Board of Directors is drawn equally from industry, the universities and the federal government. The Corporation is funded through a block grant from NSERC and runs national competitions for the design and test equipment needed by the universities. The equipment is owned by the Corporation and loaned to the universities.

A very high level of university-industry collaboration has therefore led to a unique approach for the support of training and research in very large scale integrated circuits. To date, over 20 universities have received equipment through this mechanism and Northern Telecom is processing (at no charge) increasing numbers of increasingly sophisticated designs. (Northern's total contribution to the project can be valued at about $0.7 million annually.) Furthermore, the two communities have extended their planning efforts and a new and very major proposal has been submitted to NSERC. It calls for the construction of two institutes for advanced research in microelectronics and the strengthening of the current university research efforts. The facilities would be managed by the CMC and available to both industry and the universities. The proposal has been approved in principle by NSERC, but awaits a government funding decision. The five-year cost estimate of over $150 million is **not** included as part of the next Five-Year Plan. This new proposal is being dealt with as a separate but important research initiative, one that is viewed as being fundamental to the long-term health of the Canadian microelectronics industry.

Management Mechanisms: Industrial input into the development and operation of NSERC's programs is a vital element of Council's overall effort to build better university-industry linkages. Not only has an Advisory Committee on University-Industry Interface been established to help guide Council's initiatives, but there has been, as noted elsewhere, a significant increase in the direct industrial input into all of NSERC's activities. Participation on NSERC's committees entails a significant amount of **voluntary** effort within a tightly-planned schedule. In spite of the difficulties this presents, up to 8 representatives from Canadian industry have sat on the Council itself at any one time and 63 others are now contributing through membership on peer-review and other committees. The interaction of specialists from both sectors is a key to enhanced university-industry cooperation and understanding, and NSERC intends to continue its efforts to this end.

Summary

The foregoing discussion indicates a concerted effort by Council to reinforce the interaction already existing between two vital components of Canada's overall research and development activity. Progress is being achieved, but much more is possible. Improved communications between the various players is the key to future success. And there must be success in this endeavour; the interdependence of the respective efforts is too strong to be denied. To quote the words of one industrial member of Council:

> "Industry can no longer afford to do all of the long-term research it needs to survive; thus it is no longer looking at universities simply as an inexpensive source of trained people, but also as a vast reservoir of expertise which can perform that urgently needed long-term effort. Industry's fear of losing its competitive edge because of lack of such research has had, and will have, many positive spin-offs in the future".

NSERC's initiatives have been, and will be, aimed at facilitating and accelerating that cooperation.

CHAPTER 6

THE UNIQUE NEEDS OF ENGINEERING RESEARCH - HOW HAVE THEY FARED?

The first Five-Year Plan identifed important distinctions between engineering research and research in the basic sciences:

> "In the basic sciences, the spectrum of research activities is skewed towards the new knowledge and investigation end, but activities cover the whole spectrum. In the applied sciences and engineering the spectrum of research activities is skewed towards the application, problem-solving and technological end, but again activities have to cover the entire spectrum.
>
> However, the constraints on funding within the NSERC program and the limitations on university facilities and support mechanisms have contributed to a slow development of the problem-solving and applied activities which are so important to engineering. These and other factors have imposed a distribution of activities which is scarcely distinguishable from the distribution appropriate in the pure sciences. Accordingly, the type of research supported by NSERC in engineering has had a tendency to evolve along the lines of the research supported in the basic sciences. Two main factors are responsible for this particular evolution. The first has been the natural tendency for engineering professors to model their research and research proposals on the proposals of scientists in the natural sciences who have had a longer tradition in research and have already achieved greater national and international recognition, mainly through publications. The second is the tendency of the grant selection committees reviewing engineering research proposals to use the same criteria as in other areas of the natural sciences."

In a concerted effort to remove these constraints to effective engineering research and development, NSERC embarked upon a process of "liberalization" on several fronts beginning with the graduate schools themselves. In 1979, there was a marked lack of interest in graduate study by Canadian engineering students. Job opportunities at the Bachelor's level were plentiful and the further investment of money, time and effort to get a higher degree did not appear financially attractive. In addition, many students viewed university research as being far too abstract and removed from the problems they wished to tackle.

The following is a brief summary of some of the actions taken by NSERC and the results achieved. A far more comprehensive review was carried out in 1982-83 by Dr. R.J. Kavanagh, then Dean of Graduate Studies and Research at the University of New Brunswick on leave as a Visiting Researcher at NSERC. Extracts from the summary of Dr. Kavanagh's report are included in Appendix V along with a list of the actions by Council in response to his various recommendations. The full report is available upon request.

New Indicators of Research Excellence and Productivity

In 1980, the Council issued guidelines to the research community and to the engineering grant selection committees, entitled "Research in Engineering". These guidelines redefined the indicators of excellence and productivity used in the review of research grant applications and the assessment of track record. The engineering document (copy in Appendix V) noted that, in addition to refereed publications in research journals, the following would be taken into account in the review of grant applications in engineering:

- general and specialized publications;
- conference presentations;
- documented industrial contributions;
- research interactions with industry or government;
- patents (when appropriate);
- other contributions leading to commercially viable products, processes or services

These new indicators were aimed at making a distinction between scientific and engineering productivity. They recognized the difference that the engineering community had been espousing for years. And yet, a built-in inertia within that same community was largely responsible for a two to three year lag in the widescale implementation of the indicators. Indeed, grant selection committees were slow to alter past practices, problems were encountered in documenting "industrial contributions", and grant holders were reluctant to tamper with application procedures that had brought them success in the past. Dr. Kavanagh assessed this reaction in some detail in his report, but was able to conclude that:

> "Within the faculties of engineering there is increasing emphasis being placed upon research and development activities which are related to the "real world". Of course, one cannot attribute this trend solely to form 135 (the new procedure), but it must certainly have contributed towards the shifting nature of engineering research in the universities".

Dr. Kavanagh's study was carried out in late 1982 and early 1983. In the two subsequent years, much more progress has been realized and the new indicators can now be said to be almost fully accepted and implemented. What is equally encouraging is the fact that other disciplines have expressed interest in this expanded process of review, so much so that these indicators of productivity are now contained in a document entitled "Research in Engineering and Applied Sciences" and are being used by peer review committees in a number of disciplines.

The State of Graduate Schools in Engineering

As noted earlier, a number of Canada's graduate schools in engineering were in difficulty in the late 70s due to a general lack of interest on the part of Canadian students in pursuing graduate studies. In some cases the schools were being sustained largely by the enrolment of foreign students. Given the projections of need for highly trained researchers in engineering, this situation had to be addressed urgently.

Council could have differentiated its scholarship stipends to reflect the supply and demand for various disciplines. Certainly there were strong arguments from faculties of engineering that a "bonus" be added to Postgraduate Scholarships in engineering. However, the Council resisted this course of action on the grounds that the relative market demands for various discipline groups can change rapidly, that not all engineering disciplines faced equal pressures and that graduates in other disciplines, e.g. computer science, were in even greater demand. Furthermore, while it was recognized that the financial sacrifice involved in undertaking graduate studies was a real barrier to graduate enrolment, other factors also came into play. Students sometimes perceived a lack of relevance of some of the research programs of professors and this either discouraged them or turned them towards schools in the United States; in addition, starting salaries offered by employers in Canada did not provide a sufficient bonus in recognition of a Master's or Doctoral degree.

NSERC could not remedy this last problem, but took action on a number of other fronts:

- all scholarships were returned to a real spending power equal to that of 1970;
- graduate students were permitted to "top up" NSERC scholarships with other awards;
- a program of Industrial Postgraduate Scholarships was launched in 1983 that promised to be particularly attractive to engineers.

While these specific actions were being pursued, the whole engineering research effort in university laboratories was being revitalized by the other measures described in this chapter. In addition, as a result of the economic recession, the market demand for engineers at the Bachelor's level by industry fell dramatically starting in 1982 and the pursuit of graduate studies became more attractive, making it difficult to quantify the success of specific actions. Table 27 and Figure 18 record the increases that have occurred over the past five years in terms of the number of applications by engineers and awards accepted. The challenge ahead will be to sustain this interest in graduate studies in the face of economic recovery.

Table 27

Participation of Engineers in NSERC's Postgraduate Scholarship Program
(In Numbers (and Percent of Total))

	Base Year	First Five-Year Plan				
	1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Applications	692 (21.2)	718 (22.2)	834 (22.8)	844 (22.5)	1,264 (26.6)	1,354 (24.6)
Awards						
Offered	463 (26.4)	470 (24.5)	505 (24.0)	552 (24.7)	808 (29.4)	780 (27.6)
Declined/Deferred	176 (40.1)	134 (33.0)	147 (33.5)	119 (26.6)	163 (34.1)	83 (19.5)
Held	287 (19.6)	336 (19.8)	358 (19.2)	433 (21.5)	645 (25.5)	697 (26.0)
Success Rate* (%)	66.9	65.5	60.6	65.4	63.9	57.6

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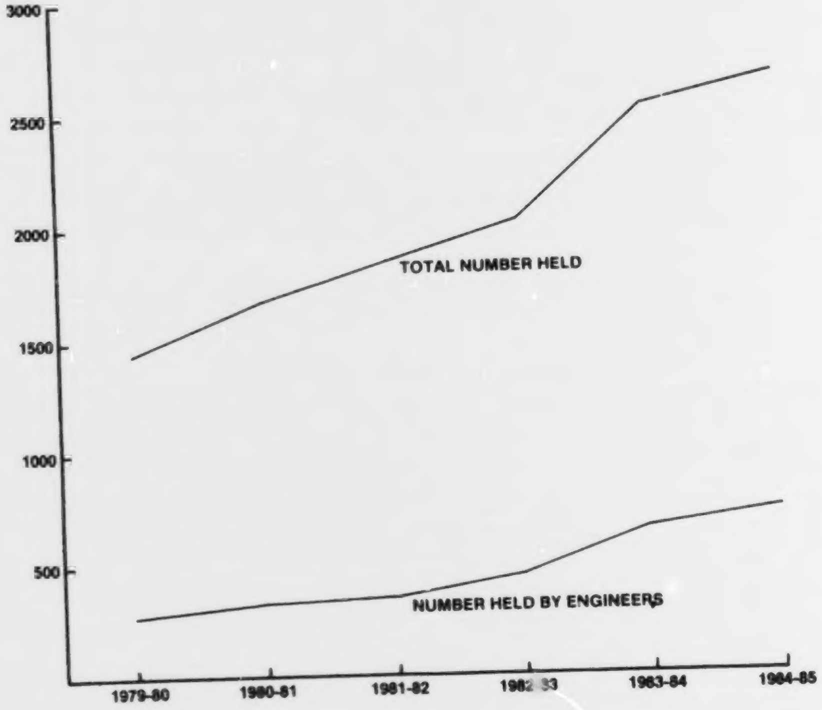
* Includes renewal applications and awards.

Figure 18

PGS Awards Held from 1979-80 to 1984-85
(Total awards and number held by Engineers)



Participation and Success of Engineers in Competitions

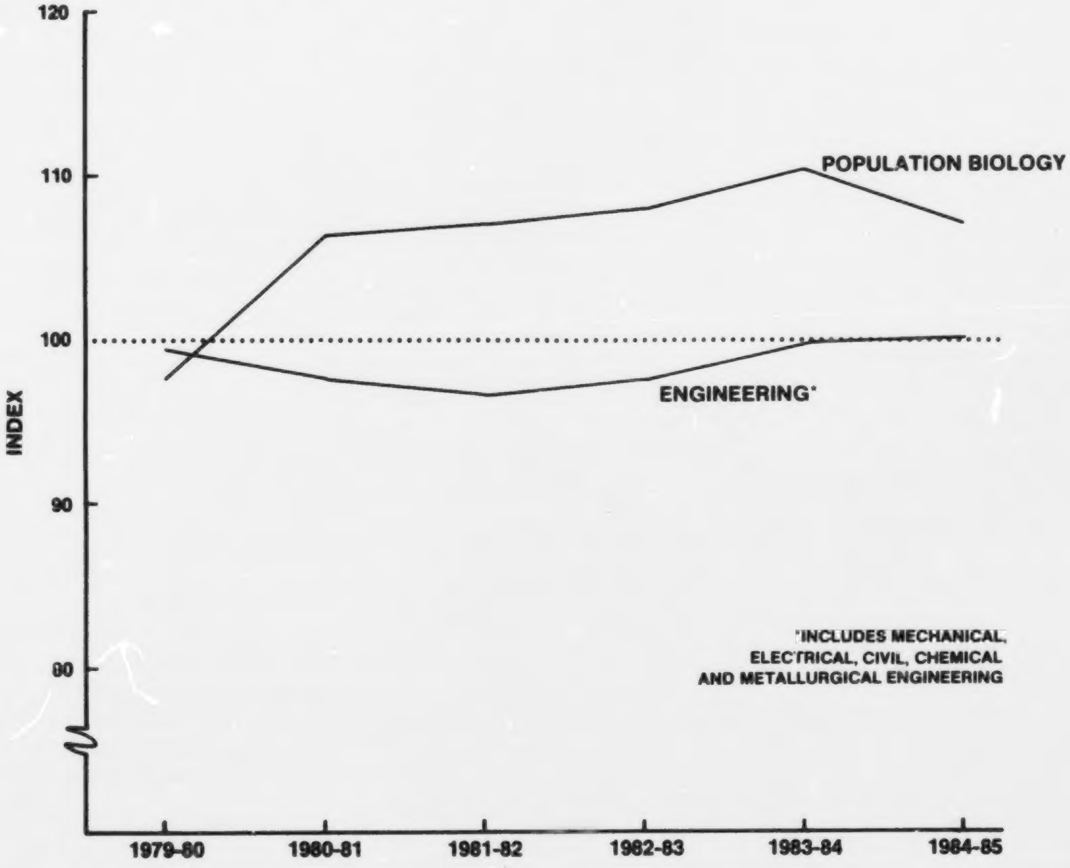
Operating Grants: There have been, and continue to be, expressions of concern that engineering disciplines are not getting their "fair share" of the total budget of the Operating Grants program of NSERC. This argument is reinforced by references to the average grant awarded to engineers as compared to that of say chemistry or animal biology. (A listing of average grants is given in Table 16, page 48). A counter argument points to the long-term record of lower selectivity of the engineering grant selection committees as compared to other disciplines. In other words, the average grant is a product of both the total money available and how many applicants receive an award.

In this regard, the Council has taken two steps; first, it has accepted a recommendation of its Allocations Committee that an "across the board" budget increase of 10% be given to the engineering committees; second, it has pushed for greater selectivity by all grant selection committees, but in particular by the engineering committees.

The end result of these two efforts is not yet fully apparent. While the engineering committees have become more selective in their awards, their actions in that regard have, on average, come later and have been less aggressive than those of other disciplines. In any event, Figures 19 and 20 show the progress of the combined average grant of the four major engineering committees (1) compared to the average of all NSERC awards and the relative selectivity of these same groups of disciplines. For comparison sake, actions by the Population Biology committee, which has been particularly selective in its awards for a number of years, are also displayed. That Committee received a special, but modest 3% budget increase starting in 1982-83 to reflect the escalating cost of field work.

Figure 19

Comparison of Average Individual Operating Grants (including instalments)
(NSERC Average Grant Indexed to 100)



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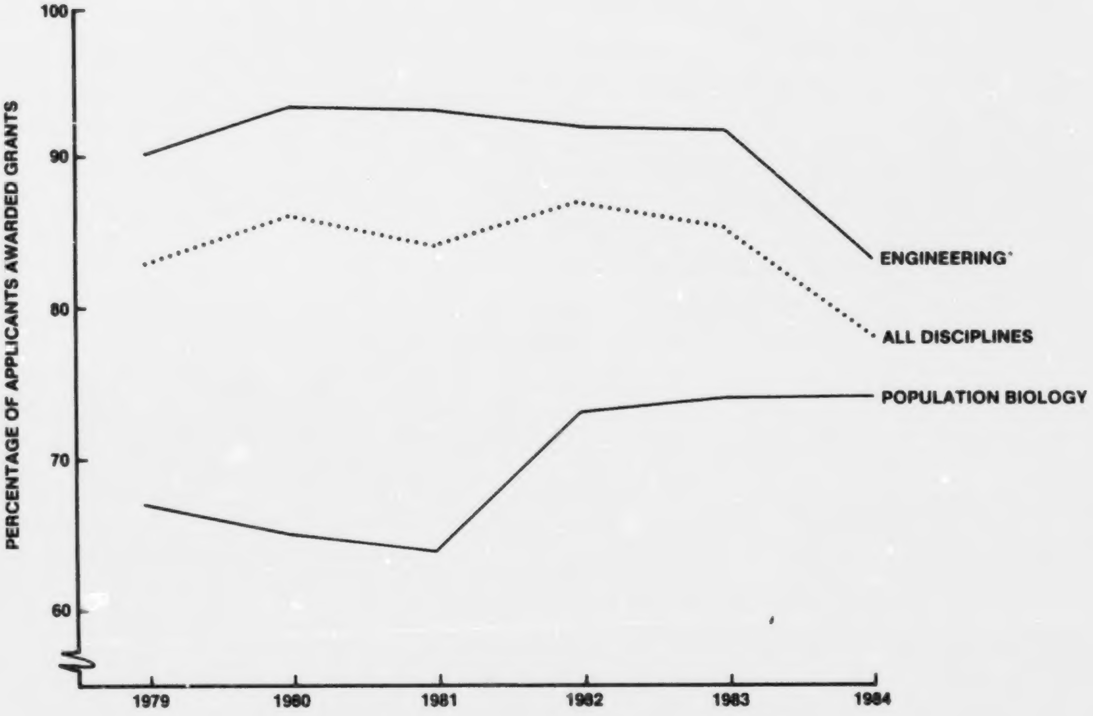
(1) "Industrial Engineering" includes a significant community of researchers from non-engineering faculties and is therefore excluded.

Figure 20

Comparison of Success Rates in Individual Operating Grants Competitions



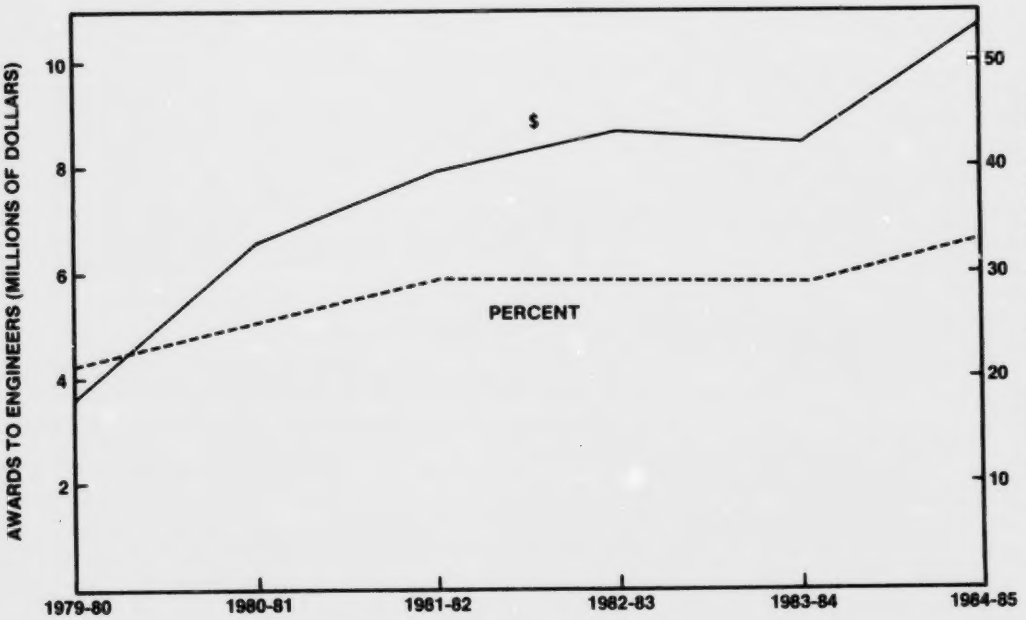
*INCLUDES MECHANICAL, ELECTRICAL, CIVIL, CHEMICAL AND METALLURGICAL ENGINEERING

While it is recognized that Figures 19 and 20 do not reflect the full story, they do illustrate the long-term impact of selectivity on the average award. The Council would be criticized quite rightly by other disciplines if it were to reward lack of selectivity by making special adjustments to bring the average grants of less selective disciplines closer to that of the more selective ones. In fact, such criticism has already been made. However, the counter argument made by engineering spokesmen is that a smaller but select percentage of the overall engineering faculty are interested in research and end up applying to NSERC; the success rates and average grants should reflect that element of "preselection". The Council's Allocations Committee is still considering these and other arguments, but, to date, has not recommended further special adjustments.

Strategic Grants: While not all engineering disciplines have benefitted equally from this program, its impact on engineering research as discussed in Chapter 5 and summarized by Figure 21 has been considerable and is continuing to grow. In 1984-85, new awards and instalments of awards made to engineers, or to teams led by engineers, amounted to $ 10.7 million, or 33% of the total budget. Given the strong (65%) participation of engineers in the new area of Industrial Materials and Processes, their overall percentage involvement is expected to continue to climb. For comparison, engineers represent only 26% of the total population receiving NSERC Operating Grants in 1984-85. Clearly, the type of research and the areas of research being promoted by Strategic Grants are of particular benefit to engineering faculty and their graduate schools.

Figure 21

Engineering Participation in Strategic Grants
(millions of constant 1984-85 dollars)



University-Industry Programs: Given the requirements for industrial contribution, this program is particularly well suited for engineering R&D and in most program elements the engineering community has seized the opportunity. Consider the following:

- 51% of the 513 Industrial Undergraduate Student Research Awards in 1984-85 went to engineers;

- As noted earlier, 65% (17 awards) of the Industrial Postgraduate Scholarships awarded to date have gone to engineers;
- 52 or 25% of the Industrial Research Fellowships have been granted to engineers;
- On average, 50% of the 10 to 12 Senior Industrial Fellowships awarded annually go to engineers;
- Of 41 on-going PRAI projects, 68% involve engineers or engineering departments;
- Engineering participation in cooperative R&D activities is also high. About 60% of the dollars approved as first instalments between February 1, 1984 and March 31, 1985, for Cooperative R&D Projects and Shared Equipment and Facilities involved engineers or engineering departments specifically. Of the 11 Industrial Research Chairs involved with the 9 awards approved by that date, 5 had been to engineering departments.

National VLSI Design Network: Engineering faculty and students have been the major beneficiaries of this facility which is being operated by the Canadian Microelectronics Corporation, with NSERC funding. (Chapter 5, page 73) Up to March 31, 1985, a total of $12.9 million (constant 1984-85 dollars) had been invested in this networking operation and a total of 35 pieces of equipment (design or test stations) had been purchased and loaned to faculty. Of that total, 32 have gone to electrical engineering or related engineering departments.

Equipment Grants: As shown by Table 10 (Page 34) engineering researchers have received 28% of the total funding for equipment over the past five competitions. This represents a total of $32.1 million in awards over that period (in constant 1984-85 dollars). Furthermore, Table 11 on page 35 shows that relative to other disciplines, engineers have experienced a high level of success through the equipment competitions of NSERC, receiving 23 cents of equipment funds for each operating grant dollar as compared to 19 cents for all disciplines combined.

University Research Fellowships: This program has been singled out for criticism by some elements of the engineering community because of the limited number of engineers receiving fellowships. On the surface, the numbers support this criticism; only 16% of all awards made to date have gone to individuals nominated by engineering departments even though that community represents about 26% of all Individual Operating Grant recipients. Clearly, there is an imbalance and this has led to proposals that a quota system be established.

However, further analysis is warranted. First, the program is responsive by nature and, to date, only 18% of the nominees have been engineers. The average success rate of engineers who are nominated is therefore only marginally below the overall average: 23% vs. 26%. In effect, this means that the adoption of a quota system would result in awards to engineers having qualifications below those of unsuccessful applicants in other disciplines.

Second, the program was never intended by NSERC to be used by the universities as an alternative method of hiring permanent staff; rather, it was designed to provide temporary academic research positions for exceptional PhDs who would make excellent faculty members, **but for whom no faculty opening existed.** In many engineering disciplines there is strong competition for the limited number of young PhDs who are currently available. These individuals have a choice between a career in university or industry in Canada, or employment in the USA, particularly in areas such as digital electronics and space technology. Canadian engineering faculties are finding it difficult to recruit young faculty members; thus, permanent and funded positions are remaining vacant. In some respects, the University Research Fellowships program is not appropriate as a solution to the manpower supply problem which currently afflicts some engineering discipines. That problem will only be resolved when the numbers of Canadians receiving PhDs in the engineering disciplines is increased.

The Council's position, therefore, is that it sees no rationale for applying a quota system to the University Research Fellowship Program. If the Council determined that **too many** fellows were being appointed in a particular discipline in relation to future employment prospects, it could impose a ceiling on the number of awards for that discipline. This would not mean, however, that the standards of quality for other disciplines would be reduced just to permit the awarding of a set number of fellowships each year.

Advisory Committee on Engineering (ACE)

Recognizing that existing and emerging issues in engineering research warranted a separate advisory body, Council established the Advisory Committee in 1983 with membership drawn from the academic and business communities. The list of members and the terms of reference of the Committee are given in Appendix V. The Committee is expected to help Council analyse the problems facing the engineering community, to propose corrective action and to help build stronger linkages with the industrial community.

Summary

NSERC is committed to the development of quality engineering research and research training in Canadian universities. The programs that have either been expanded or initiated over the course of the first Five-Year Plan have done much to achieve that objective. While concerns still exist about the level of the average Operating Grant in engineering, the total funding available to engineers through all of NSERC's programs has grown dramatically over the past five years. This progress has been achieved in large part through the implementation of programs designed to bring the researcher into closer contact with the user community. Given that engineers have argued that it is the development and demonstration aspect of their work that separates them from truly scientific endeavour, it is now up to the engineers to make even more effective use of these programs.

CHAPTER 7

NSERC'S NATIONAL DIMENSION - TRYING TO MAINTAIN A BALANCE

NSERC faces many challenges, but none so difficult as the challenge of maintaining an optimum balance of its programs, of its support for various disciplines, and of its support in various regions of Canada. This chapter concentrates on the ever-contentious issue of regional and linguistic balance, but also presents brief commentary on the efforts made to help overcome the problems of isolated universities, of research in the north and of forestry research.

Regional Balance

NSERC's fundamental policy is to support high quality work done by the best researchers wherever they may be and in whatever field they may choose within the overall NSERC mandate. Because of this focus on excellence, NSERC does not predetermine a regional distribution of its funds. Nor does the Council use quotas in making the awards. Regional or provincial quotas, or quotas by discipline or field of research, are not compatible with the support of excellence and high quality research as assessed by NSERC's peer review process.

Support of excellence in research is fundamental to the maintenance of NSERC's operation and of the university research effort. Researchers and students are highly mobile and research results are easily transferable, crossing provincial, regional and even national boundaries in pursuit of new challenges, opportunities and applications. Therefore, the Council believes that the development of a national research capacity of high calibre, and the provision of quality products (i.e. knowledge and trained research talent) provide the best possible benefit to Canada as a nation. This research capacity can then be put to work on a variety of problems and opportunities, irrespective of where the challenges occur and where the research results are needed.

Although NSERC's major activities have a truly national scope and are concerned with the development and maintenance of a nation-wide research capacity, the Council is sensitive to the regional impact of its programs and also recognizes that not all Canadian universities have the same level of research maturity or intensity. After-the-fact analyses of program expenditures by province, by region or by discipline normally provide the first indication that special developmental support may be needed in some areas. The results of a region by region analysis are shown in Tables 28 and 29. The first of these tables is a simple reporting of the total value of the awards won by individuals in each province. It shows only marginal percentage variations over a five year period. The information presented in Table 29, however, is premised on the Council's position that a meaningful measurement of the regional distribution of awards can only be made on the basis of those who actually applied for them. Table 29, therefore, assesses, for two points in time, the regional interest in NSERC's programs and the relative success of those who applied.

Table 28

Distribution of Total Program Expenditures by Province
(Millions of constant 1984-85 dollars (and percent))

Province	Base Year 1979-80		First Five-Year Plan* (1) 1980-81		(2) 1981-82		(3) 1982-83		(4) 1983-84	
British Columbia	23.1	(13.0)	27.4	(12.7)	28.5	(11.9)	31.4	(12.3)	32.8	(12.1)
Alberta	15.7	(8.8)	19.6	(9.1)	22.2	(9.3)	22.8	(8.9)	23.9	(8.8)
Saskatchewan	7.0	(3.9)	7.9	(3.7)	8.1	(3.4)	10.6	(4.2)	12.1	(4.5)
Manitoba	6.7	(3.8)	8.7	(4.0)	9.0	(3.8)	10.7	(4.2)	9.5	(3.5)
Ontario	76.0	(42.7)	92.1	(42.9)	103.3	(43.2)	109.0	(42.8)	116.1	(42.8)
Quebec	35.5	(19.9)	42.4	(19.7)	48.6	(20.4)	51.2	(20.1)	55.0	(20.4)
New Brunswick	3.6	(2.0)	4.6	(2.2)	5.3	(2.2)	5.3	(2.1)	5.9	(2.2)
Nova Scotia	6.4	(3.6)	8.2	(3.8)	9.1	(3.8)	9.3	(3.6)	10.1	(3.7)
Prince Edward Island	0.1	(0.1)	0.1	(0.1)	0.1	(0.1)	0.2	(0.1)	0.1	(0.1)
Newfoundland	3.9	(2.2)	3.9	(1.8)	4.5	(1.9)	4.4	(1.7)	5.1	(1.9)
Provincial Total	178.0	(100.0)	214.9	(100.0)	238.7	(100.0)	254.9	(100.0)	270.6	(100.0)
Other in Canada	3.7		3.9		4.5		6.5		12.7	
Outside Canada	3.4		3.7		3.8		4.3		5.1	
Total Expenditures:										
- constant dollars	185.1		222.5		247.0		265.7		288.4	
- current dollars	118.4		158.9		196.9		238.7		274.6	

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* Provincial summary not yet available for 1984-85.

Table 29

Regional Dimension of NSERC Programs, 1976-1984
(in percent of national total)

Elements	Atlantic		Quebec				Ontario		Prairies		B.C.	
			Francophone		Anglophone							
	75-76	83-84	75-76	83-84	75-76	83-84	75-76	83-84	75-76	83-84	75-76	83-84
Full-time professors	10.9	12.2	17.0	15.9	7.0	7.8	37.8	36.8	18.1	18.3	9.2	9.0
Operating grant applicants	9.4	9.8	12.5	13.3	7.3	7.5	41.6	40.7	18.4	18.1	10.8	10.6
Operating grant recipients	9.1	9.3	12.2	12.8	7.1	7.5	42.4	41.7	18.2	18.1	11.0	10.6
Total operating grants	7.1	7.3	9.4	10.2	7.2	7.7	45.7	44.6	18.3	17.2	12.3	13.0
Funds awarded under all NSERC programs	7.2	7.8	12.7	13.2	7.3	7.2	44.1	42.9	17.3	16.8	11.4	12.1
NSERC grant selection committee membership from 1975-83	10.7		23.7				36.1		17.4		12.1	

The reader is cautioned that the number of "full-time professors" given for each region is only an approximation based on published data and, for 1983-84, consultation with some Quebec universities. Appendix VI provides more data.

The following conclusions can be drawn:

- NSERC's awards, made on the basis of individual excellence, and measured against the actual numbers of applicants, result in a remarkably good regional distribution of funds;

- the regional distribution seems to have improved marginally over the past eight years, with **relative** gains in funding in Atlantic Canada, Quebec and British Columbia, but drops in Ontario and the Prairies. Deviations of **total** funding vs. numbers of applicants were very small in 1983-84; Atlantic Canada had 9.8% of applicants, but only 7.8% of the dollars while Ontario had 40.7% of applicants and 42.9% of the dollars;

- the distribution of operating grants is still the best measure of individual success in a national competition. The greatest relative increase in applications has come from francophone universities in Quebec; that is also where the greatest relative increase in the number of operating grants is evident. Ontario and the Prairies have seen their shares drop;

- Francophone universities in Quebec, however, still had the largest variation between the number of successful **applicants** in 1983-84 and the resulting **funds** awarded through Operating Grants to those applicants (12.8% of grant recipients but only 10.2% of funds). In fact, the spread of 2.6 percentage points is only marginally better than that of 2.8% in 1975-76. In other words, more faculty at these universities are applying, more are being successful, but the average value of awards still lags behind the national average; the gap is made up through other NSERC programs;

- the low participation rate by professors in francophone universities and in Atlantic Canada remains a problem; in contrast, the rate of applications from Ontario is well above the national average.

Overall, the data suggest a marginal improvement since 1975-76, but a continuing need to increase the rate of participation in Quebec and Atlantic Canada as well as the value of the average award in those areas. Some of the factors inhibiting participation, however, may be beyond NSERC's control, e.g. a lack of a research background or motivation on the part of some, a younger and less experienced research force, or perhaps funding from some provincial sources which may be considered sufficient. Council's programs designed to assist universities and researchers in improving their research capabilities are reviewed briefly below.

Research Development Program

This particular initiative has two distinct parts, a subprogram of special research development project grants and a subprogram of support for young francophone faculty (attachés de recherche). Each is reviewed separately below.

Research Development Project Grants: Launched in 1971, this program has enabled universities to identify groups of faculty members with good **research potential.** To obtain special research support, these teams or individuals must identify the factors inhibiting their research activities and propose ways of overcoming them. The proposals are reviewed separately from the operating grants program, although grant selection committee members are invited to comment on the potential of the applicants. The ultimate objective is to bring these researchers to a point where they can compete successfully in the national program.

Initially, Research Development Project Grants were limited to francophone universities, but were extended to some small Maritime universities in 1972, and to six other small universities in 1984. The rationale for special support at these locations includes:

- the more limited reservoir of highly qualified manpower for the francophone universities;

- the lack of a research tradition in the natural sciences and engineering in most of the francophone universities and in small institutions where undergraduate teaching has been, and remains, the primary call on faculty time;

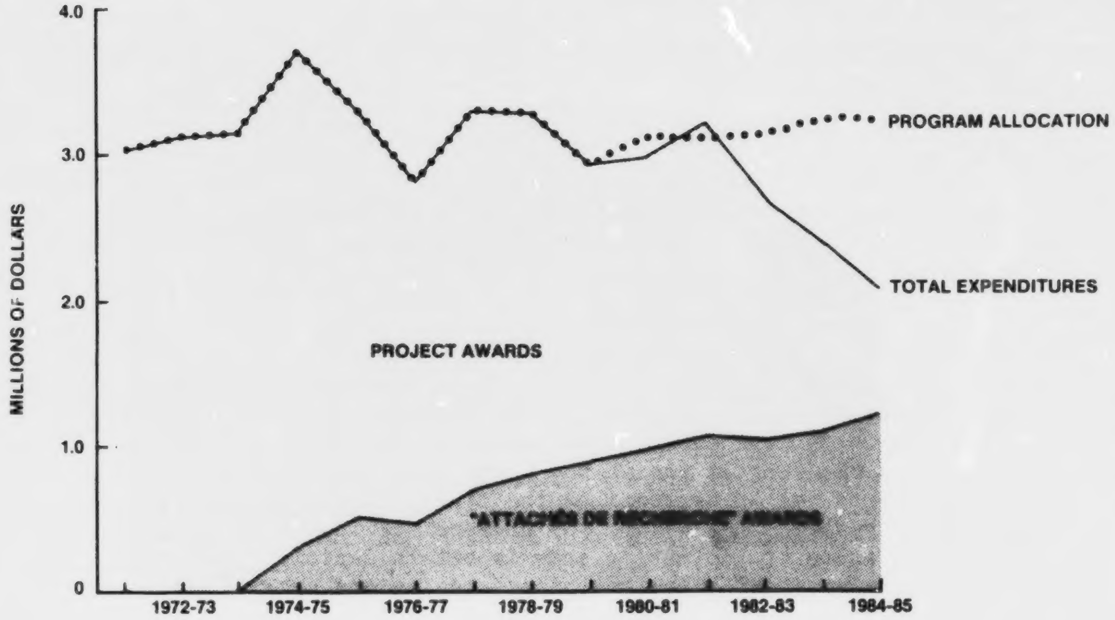
- the special difficulties experienced by small universities in reaching a critical mass of human resources and in acquiring adequate facilities for research.

The results achieved through this fifteen year effort are currently being analyzed in considerable detail and will be reviewed by Council during 1985. On the surface, one can see indications of both success and failure. As indicated by Figure 22, the budget allocated to the initiative has not changed dramatically. However, in recent years the number of worthy applications has not been sufficient to warrant committing the allocated budget, although it must be noted that the program criteria have been significantly tightened. Furthermore, the suggestion has been made that perhaps some of the more research intensive universities presently in the program are at the stage where such special assistance is no longer warranted or needed; at the other end of the spectrum, a lack of emphasis on research may negate any prospect of long-term success as we presently measure it. Clearly, some important decisions are called for regarding the most effective way of addressing the special problems that remain.

In this regard, it must be noted that the difficulties of francophone universities in federal competitions for research funds have been examined in considerable detail by the Government of Québec. In 1983 and 1984, several reports by the Conseil des universités du Québec expressed concern over the situation and proposed remedial actions. The reports recognize that, in the last decade, Québec universities have shown real progress in many research sectors. However, francophone universities remain at the bottom of a list of 30 comparable universities with respect to the average grant per faculty in fields covered by NSERC. Since francophone universities are reported to be generally among the lowest in Canada in terms of the proportion of faculty with Ph.D's, these reports provide some rationale for NSERC's conclusion that many eligible faculty do not apply for federal funds. The reports do not blame NSERC for this, but point to a plethora of causes and urge the universities to set basic objectives which will encourage their professors to become more active in research. As a result of these reports, it is possible that closer federal-provincial collaboration in this area will develop in the near future and will clearly influence the redesign of NSERC's program.

Figure 22

Research Development Program Funding
(millions of constant 1984-85 dollars)



With regard to the small universities in the Maritimes that have participated in the Research Development Project Grants program for some time, the ongoing review will hopefully help identify the reasons for the mixture of success and failure noted to date. Preliminary indications are that the priority being placed on research itself varies considerably, as does the degree of determination by the institution to identify priority areas and pursue them. This, in turn, lends support to one of the important conditions associated with the recent expansion of this program to six other small universities across Canada; to be eligible to apply for these special grants, the institution must prepare a research plan which clearly identifies priorities. To date, one year after this offer was made to the six universities, only three have responded. Perhaps this is indicative of the problems that a small, but multi-disciplinary university has in selecting priority research areas. Past experience has shown, however, that a willingness to focus one's research effort is a prerequisite for effective use of NSERC's research development funds.

One final comment concerning the dilemma of small universities is necessary. During discussions over the past several years the staff of the Council has received mixed messages concerning the priority that the various provincial governments place on research at some of the small Maritime universities. Some observations suggest that the institutions should content themselves with an effective teaching role, and certainly the teaching loads placed on the faculty leave very little time for research. This matter will be explored during the ongoing review and, hopefully, the governments concerned will make their positions both clear and public. The programs of NSERC cannot by themselves develop excellence in research nor does the Council wish to pursue that effort if it is contrary to the objectives of the responsible provincial governments.

"Attachés de Recherche du CRSNG": In recognition of the special problems faced by francophone universities in the hiring of highly qualified research faculty, a special support program of Attachés de Recherche was instituted in 1974. Since that time, a total of 70 such awards have been made and 37 of them are currently ongoing. Of the 33 former Attachés, 21 have found permanent employment at their host institution or at another Canadian university.

A successful applicant to the Attachés de Recherche Program is appointed to a position equivalent to that of an assistant professor at the host university. Originally, NSERC paid the full salary of the individual for a finite five-year term at which time the university was expected to accept that responsibility. Under the current regulations, NSERC accepts responsibility for the starting salary plus any annual increments for inflation as determined by the Council; increments for merit, etc. are met by the university. During years 4 to 5 of the initial five-year term, provided the university offers the equivalent of a tenure-track position to the incumbent, NSERC will provide the same five-year phase out formula offered to holders of its University Research Fellowships, i.e. 100%, 90%, 75%, 50% and 25% of the level of NSERC support in year five.

Table 30

Number of Awards and Expenditures for "Attachés de Recherche du CRSNG"
(Thousands of constant 1984-85 dollars)

							First Five-Year Plan				
	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Number of Awards Held:											
- New	7	6	5	5	6	6	7	6	6	7	9
- Total	7	11	18	19	20	24	24	28	28	32	37
Total Expenditures:											
- constant dollars	307	518	465	718	812	889	999	1067	1047	1146	1221
- current dollars	133	250	246	408	491	569	714	850	941	1091	1221

The retention rate noted above is a good indication of the success of this program. Furthermore, some of the former Attachés de Recherche have become leaders in their research fields; one was recently presented with NSERC's most prestigious award, the EWR Steacie Memorial Fellowship. Accordingly, there is no doubt that this particular initiative, which complements the University Research Fellowship Program, should be continued and expanded as warranted by the quality of the applicants. One note of caution must be voiced, however. Recently, the Quebec Government announced its intention to pursue a "Programme d'Actions Structurantes" under which it will invest $75 million by 1991-92 to establish 40 teams of researchers in priority areas. To the extent that this initiative is designed to support the salaries of new young faculty it will be looking to the same limited pool of talent as the Attachés de Recherche and University Research Fellowship programs. Some coordination of effort will be needed to increase the size of the pool, not just deplete it.

Table 30 presents the level of NSERC funding for the Attaché subprogram over the past eleven years.

Isolation Supplements

Researchers at some Canadian universities have to work against the twin obstacles of small size and isolation. The latter barrier to an effective research program presents itself in a number of forms, but the major impediments are the lack of sophisticated research libraries and the lack of frequent communication with colleagues working in the same field of endeavour at other institutions.

In an effort to give these faculty a better chance to compete in national competitions for research awards, the Council launched a modest, but important program of Isolation Supplements in 1981. The supplements are awarded as "block grants" to the presidents of small universities located at least 100 kilometers away from the next closest university. In 1984-85, the awards were calculated on the basis of $620 for each faculty member receiving an Operating or Strategic Grant. Sixteen universities now receive funding of this nature.

Table 31 presents the relatively short history of investment through this initiative. While very modest in budget, and very inexpensive to administer, this program has received endorsement by the recipients that is out of all proportion to the funds involved. It is providing modest, but flexible support for increased communications; communications via new computer access to information banks, or through visits to other research centres.

Table 31

Isolation Supplements

Total Expenditures	Year(1) 1981-82	1982-83	1983-84	1984-85
Thousands of constant 1984-85 dollars:	151	156	180	182
Thousands of current dollars:	120	140	171	182

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(1) Program initiated in 1981-82

Northern Supplements

During the past five years the Council also embarked upon two programs to provide special assistance to particular research endeavours. One of these encourages research in Canada's north and represents an effort to help combat the extremely high cost of logistics, safety, etc. while working in that area. Transportation costs have escalated at a much faster rate than the average inflation allowances that NSERC has been able to include within its grants. Effective research in the north was becoming almost prohibitive in spite of the excellent support that is provided in many areas by the Polar Continental Shelf Project of Energy, Mines and Resources, Canada.

Northern Supplements are awarded through a special competition following the regular February competition for Operating Grants. The awards take into account recommendations from the various grant selection committees involved and demonstrated need for supplementary funding. The amounts and the disciplines involved are presented by Table 32. These funds, combined with the help of the Polar Continental Shelf Project and access to industry-chartered or industry-owned aircraft, assist in sustaining a reasonable level of research effort and research training in the Canadian North.

Table 32

Northern Supplements
(thousands of constant 1984-85 dollars)

Discipline(1)	Year(2) 1982-83	1983-84	1984-85
Biology	145	144	129
Physics	18	2	2
Engineering	7	17	14
Earth Sciences	79	184	157
Total Expenditures:			
- constant dollars	249	347	302
- current dollars	224	330	302

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(1) Includes only disciplines from which applications received
(2) Program initiated in 1982-83

Forestry Development Program

The importance of the forest-based industry for Canada's economy is self evident. The depletion of our forests and a reduction of our competitive position world-wide is very disturbing, as is the current state of research being pursued in the six forestry schools of Canada. Many researchers from the forestry faculties were having difficulty competing successfully in NSERC's national competitions. The Council was concerned that many of these researchers tended to work in isolation, ignoring the excellent work being performed in other faculties or in industry and government.

In short, the pressures of teaching time, an emphasis on contract or consulting work, and a low priority given to research in many instances were, in NSERC's view, seriously threatening the effectiveness of the six forestry schools in innovative research and research training.

The Council has resisted pressures for research quotas or for a specially identified Strategic Grant area (1) as solutions to this problem. It has, however, continued an ongoing program of special postgraduate scholarships (included in Chapter 2) and postdoctoral assistantships in forestry (25 scholarships and 19 postdoctoral assistantships were held in 1984-85) and has instituted a new program of "developmental" grants. This latter program entails a number of critical requirements designed to improve the quality of the research and to promote an interdisciplinary approach. The forestry schools were invited to submit proposals with clearly identified goals and priorities, and which reached beyond the forestry schools to draw on the expertise of other faculty and of industry and government. All of the initial or draft proposals were subject to a protracted period of consultation before approval could be granted, sometimes on a conditional basis. However, multi-year awards have now been made to groups within all six schools and some assessments of progress are now being made. While no great advances have been identified as yet, it is recognized that adequate time for such changes to appear has not yet elapsed.

The Council will be monitoring the process carefully, as this special program, like all others, should be continued only if its original objectives are being met. Table 33 presents a summary of the six-year investment in special postdoctoral assistantships and in the more recent Development Grant program in forestry.

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(1) Forestry-related research can be supported through the "Open" and the "Biotechnology" areas of Strategic Grants. In 1984-85 there were 13 ongoing awards totalling over $627,000 in this field.

Table 33

Forestry Development Program
(thousands of constant 1984-85 dollars)

Component	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Postdoctoral Assistantships	242	141	312	287	246	183
Development Grants	---	---	---	223	689	374
Total Expenditures:						
- constant dollars	242	141	312	510	935	557
- current dollars	155	101	249	458	890	557

Summary

The Council recognizes that there are special circumstances that warrant special attention. However, it is firm in its view that its major programs which are rooted in the support of individual excellence through a process of national competition, should not be biased in any way to meet those special needs. Such action would not be in the best interest of science and engineering, nor of the nation itself. For the individuals concerned, a quota or regional bias of any kind would greatly diminish the rewards of having competed and won strictly on the basis of merit.

This being said, some special programs are required to deal with special problems and a number of initiatives have been highlighted by this Chapter. Furthermore, having launched such special programs, they then warrant particular attention in terms of the progress being realized in meeting stated objectives. If progress is not being made, or if the special needs no longer exist, then clearly such programs should be discontinued; they should not be viewed as ongoing initiatives of the Council. On the other hand, NSERC is prepared to devise new mechanisms where others have failed to resolve problems in research capability and manpower training that threaten a reasonable national balance.

Table 34 summarizes the total investment in the programs described in this Chapter and presents it as a percentage of the total program budget of the Council (exclusive of administration costs). Clearly it is a small part of the whole. That, in itself, reflects the generally satisfactory regional and discipline distribution of NSERC awards that flows naturally from the recognition of individual merit.

Table 34

Summary of Research Development and Special Initiatives
(thousands of constant 1984-85 dollars)

		First Five-Year Plan				
Component	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Research Development	2944	2954	3220	2678	2395	2082
Isolation Supplements	--	--	151	156	180	182
Northern Supplements	--	--	--	249	347	302
Forestry Development	242	141	312	510	935	557
Total Expenditures:						
- constant dollars	3186	3095	3683	3593	3857	3123
- current dollars	2038	2211	2937	3228	3672	3123
Percent of Total Program Budget	1.7	1.4	1.5	1.4	1.3	1.0

CHAPTER 8

COMPLETING THE PICTURE

The Council recognizes that there are limitations to a system based solely on discipline-based peer review. Indeed, earlier comments have noted the need to promote a more multidisciplinary approach in the Operating Grants program itself. Three grant programs are highlighted in this Chapter. They have, as a major feature, the element of flexibility. The first, the General Research Grants program, provides special funds to university presidents to enhance the quality of research at their university; the second, the Collaborative Special Projects Grant program, provides support for major new initiatives that do not fit into Council's more established programs; the third, the International Program, provides limited funds to promote a greater degree of interaction with scientists and engineers of other countries. Discussion of these programs is followed by a short summary of other programs not dealt with previously. The interrelationship of all the programs is shown by Figure 40 on page 182 of this report.

General Research Grants

These grants to university presidents are a longstanding program of NSERC, and of the National Research Council before it. Simply put, they provide a means by which an institution can respond to pressing research or research training needs that can best be identified and dealt with at a local level. The amount awarded to a university is determined by a formula which is based on the NSERC research grants awarded to that university in the preceding year. A minimum level of support exists to provide small universities with a reasonable level of support and to ensure continuity. In 1984-85, general research grants ranged from $15,000 to slightly over $1 million.

Council imposes very few conditions on these grants. They must be used to support research or research training in the natural sciences and engineering, and an annual summary report on the expenditures incurred is required. In 1983-84 the grants were used for the following purposes:

Research manpower support

a)	undergraduate	4.7%
b)	postgraduate	3.2%
c)	postdoctoral	4.9%
d)	other (e.g. research associates)	4.3%
	Total	17.1%

Grants to researchers

a)	research	36.8%
b)	equipment	30.5%
c)	travel	4.6%
d)	conferences	1.5%
e)	other	9.5%
	Total	82.9%

The Council is satisfied that these funds are being employed effectively. The percentage of Council's total program budget used for this program has declined somewhat in recent years. However, this trend is due to a large extent to the Council's recent emphasis on equipment and research manpower funding, items that are not reflected in the calculation of General Research Grants.

Table 35

General Research Grants Funding
(thousands of constant 1984-85 dollars)

		First Five-Year Plan				
	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Total Awards:						
- constant dollars	7,790	8,270	8,790	8,717	8,841	9,487[a]
- current dollars	4,982	5,908	7,008	7,832	8,420	9,487[a]
Percent of Total Program Budget	4.2	3.7	3.6	3.3	3.1	3.2

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[a] Awards totalling $9,486,950 for 1985-86, which were paid in March 1985, are not included in this table

Collaborative Special Projects

During its early years, NSERC offered a modest program of "Co-op Grants" in support of "increased and continuous interaction among excellent researchers by providing supplementary funds for a limited number of new and highly significant research projects". Unfortunately, the program suffered from two serious flaws: first, the budget available for Co-op Grants was in direct competition with that for Operating Grants; second, a once-a-year competition lacked the flexibility in timing so essential to experiments dependent upon foreign facilities, e.g. space launches in the United States. Because of those flaws Council was forced to conclude in 1981 that Co-op Grants were not an adequate mechanism to promote major and unique opportunities.

Accordingly, NSERC began to phase out Co-op Grants and launched the program of Collaborative Special Project Grants. Some of the unique features of the new program are:

- It has a separate budget allocation and grant selection procedures.
- Applications may be submitted at any time throughout the year.
- The review of applications takes into account the following points:
  a) the uniqueness, scientific significance and relevance of the research opportunity;
  b) the research capability of the applicants;
  c) the existence of effective leadership for the collaborative activity; and
  d) the demonstrated need for this special funding rather than an Operating or Strategic Grant.

It turns out that the new program could not have been better timed. Its flexible schedule and distinct budget solved the serious problems relative to the timing of many of Canada's commitments with respect to international scientific programs. In fact, over the first few years, the program has run the danger of being an exclusive preserve for space and earth scientists involved in major international programs. Awards in the area of space research include support of work on a UV Imager on the Viking satellite, antenna studies, work on Spacelab and Starlab and on the proposed Canadian Long Baseline Array (of radio telescopes). Earth scientists have been funded for international studies of the earth's crust and for Phase 1 of a major national program of deep "seismic-like" studies in Canada (Lithoprobe). More recently, a share of the cost of Canada's membership in the Deep Ocean Drilling Program was funded through this program. Finally, the High Energy Physics community has used this program to make a significant contribution to experiments at major nuclear accelerators in Switzerland and Germany.

While the program is still relatively new there appears little doubt that it is serving a critical need by facilitating significant Canadian contributions to major international research programs. It has become Canada's ticket for a seat at the research tables of the world. The concern for the future is that the number of requests, and in particular the size of the requests, will greatly outstrip the available funding.

Table 36 presents the short history of the funding of Collaborative Special Projects Grants.

Table 36

History of Collaborative Special Projects Grants(1)
(thousands of constant 1984-85 dollars)

	Year			
	1981-82	1982-83	1983-84	1984-85
Requests:				
- Number	2	21	25	17(2)
- Amount	83	2,666	3,454	2,240(2)
Awards:				
- Number	1	15	19	11
- Amount:				
- constant dollars	25	1,747	2,406	1,056
- current dollars	20	1,570	2,291	1,056

---

(1) Data for each year include new awards plus instalments of multi-year awards

(2) Does not include requests made in 1984-85 for which decisions will be made in 1985-86

International Programs

NSERC believes that a high degree of international mobility of both researchers and research results is a prerequisite for a strong national R&D competence. All of Council's major programs recognize this fact to some degree. For example:

- at the postgraduate level about 10% of all scholarships are approved for tenure abroad;
- about 60% of Postdoctoral Fellowships are held abroad;
- research grants can be used to support travel and research abroad or to receive foreign researchers, and;
- special programs of travel grants and conference grants (reviewed briefly later) promote interaction with the international research community.

In addition to these more general initiatives, the Council pursues three specific programs to promote international collaboration. They are:

- a program of formal Bilateral Exchanges with seven other nations;
- a program of International Collaborative Research Grants; and,
- International Scientific Exchange Awards.

These three programs, together with the flexibility provided in all Council programs, meet most conceivable requirements for international interaction. The Bilateral Exchanges provide a mechanism for exchanges with identified nations, including some where collaboration would be difficult without a formal "umbrella" agreement. In some cases, however, this process has become more of a fact-finding exercise rather than a truly collaborative research effort. The newer program of International Collaborative Research Grants, however, requires that there be common interests and efforts; it supports Canadian scientists and engineers going abroad to work with researchers of any nation. Finally, the International Scientific Exchange Awards fund Canadian researchers who receive foreign colleagues, again to work on projects of common interest.

The number and total value of the awards made in these three programs over the past five years are recorded in Table 37.

Table 37

Summary of Investment in International Programs
(thousands of constant 1984-85 dollars)

	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Bilateral Exchanges						
Number of Awards	114	64	62	69	69	90
Expenditures	290	207	203	192	249	317
International Collaborative Research Grants						
Number of Awards	-	14	41	45	57	45
Expenditures	-	52	152	133	181	164
International Scientific Exchange Awards						
Number of Awards	-	1	24	54	65	69
Expenditures	-	7	105	203	299	373
Total number of Awards	114	79	127	168	191	204
Total expenditures:						
- constant dollars	290	266	460	528	729	854
- current dollars	185	190	367	475	694	854

Other Council Programs

Completing the overview of all of the Council's various programs of support, brief commentary is given below on some of the smaller programs. Despite the relatively modest budget, these programs are very important, particularly those designed to help disseminate the results of the research being supported. This effort of dissemination and consultation is an essential link in the process of transfering research results to the user community; it is an area which requires greater attention and support in the years ahead so as to ensure maximum possible intellectual and economic benefit from the large investment in the overall programs of NSERC.

Scientific Publication Grants: These grants assist in the provision and maintenance of high quality Canadian publications, i.e. research journals, monographs or books, for the dissemination of original research results in the natural sciences and engineering. The Grant Selection Committee on Scientific Publications recommends grants for those publications which show a high publishing quality and which can demonstrate a real financial need. A recent analysis conducted by the NRC Advisory Board on Scientific Publications has shown that the NSERC supported journals are among the best Canadian scientific publications.

Conference Grants: NSERC offers limited support for scientific conferences, symposia and meetings organized by Canadian institutions and held in Canada. The research content and potential impact of the conference, as well as the degree of participation of the Canadian academic community are some of the selection criteria.

Workshops and Seminars: This is a new initiative that Council launched to:

- assess scientific and technological advances in a discipline or a field of research;

- coordinate and plan Canadian research efforts in a discipline or a field presenting special opportunities and needs for research; and,

- plan a concerted approach to the solution of new and significant research problems.

Travel Grants: In addition to supporting international research collaboration and scientific exchanges, as described in this chapter, NSERC also encourages mobility of Canadian university researchers who obtain a leave of at least six months from their institution. This encouragement is in the form of a travel grant. Applications for travel grants are reviewed by grant selection committees and are recommended for funding when the leave is deemed to be important to the individual's research career.

New Research Idea Grants: Under this program, Council supports particularly new and exciting research opportunities which have arisen suddenly during the pursuit of research undertaken with Operating or Strategic Grants, and which must be pursued without delay. Such support allows immediate follow-up and continues until such time as a new application can be made for this reseach in a regular grant competition.

Miscellaneous Grants: Under this heading, Council supports some organizations whose activities are relevant to science and technology or research and development. Examples are the Canadian Council on Animal Care (supported jointly by NSERC and the Medical Research Council), the Royal Society of Canada and l'Association canadienne-française pour l'avancement des sciences. These organizations receive annual grants from NSERC. Other activities are supported on an ad hoc basis. For example, NSERC supported a special study on women in engineering, and for the last two years the Council has had an agreement with the Atmospheric Environment Service of Environment Canada to enable the university community to access the "super computer" installed at Dorval, Québec. Other grants under this heading include the Schreyer Fellowships and a special travel fund to support fieldwork at the France-Canada-Hawaii telescope. Council used to support activities aimed at increasing the public awareness of science and technology; this function has now been transferred to the Ministry of State for Science and Technology.

Summary

Table 38 presents the total investment in these various activities over the past six years. The line items record the expenditures for the specified fiscal year. Due to the ongoing uncertainty of the Council's budget, including increases late in some fiscal years, expenditures of some of the awards have had to straddle different fiscal years.

Table 38

Summary of Other NSERC Program Investments
(thousands of constant 1984-85 dollars)

Program	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Scientific Publication Grants	710	732	680	1,283	542	476
Conference Grants	286	435	420	863	600	739
Workshops and Seminars	-	-	-	-	-	15
Travel Grants	239	214	232	307	308	303
New Research Idea Grants	*	*	*	*	36	266
Miscellaneous Grants	507	1,099	671	1,520	617	918
Total:						
- constant dollars	1,742	2,480	2,003	3,973	2,103	2,717
- current dollars	1,114	1,772	1,597	3,570	2,002	2,717

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* Included in Discipline Research Grants in these years.

CHAPTER 9

THE DELIVERY MECHANISM

When NSERC was established in 1978, it inherited the staff and the administration budget of the former Office of Grants and Scholarships of the National Research Council. The human resources of 56 person-years and the administration budget of $1.7 million reflected the fact that this unit was heavily dependent on NRC for a wide range of support services. These resources did not meet the needs of an autonomous agency, nor did they permit the changes to the tempo and thrusts of the programs clearly expected by the government of the day.

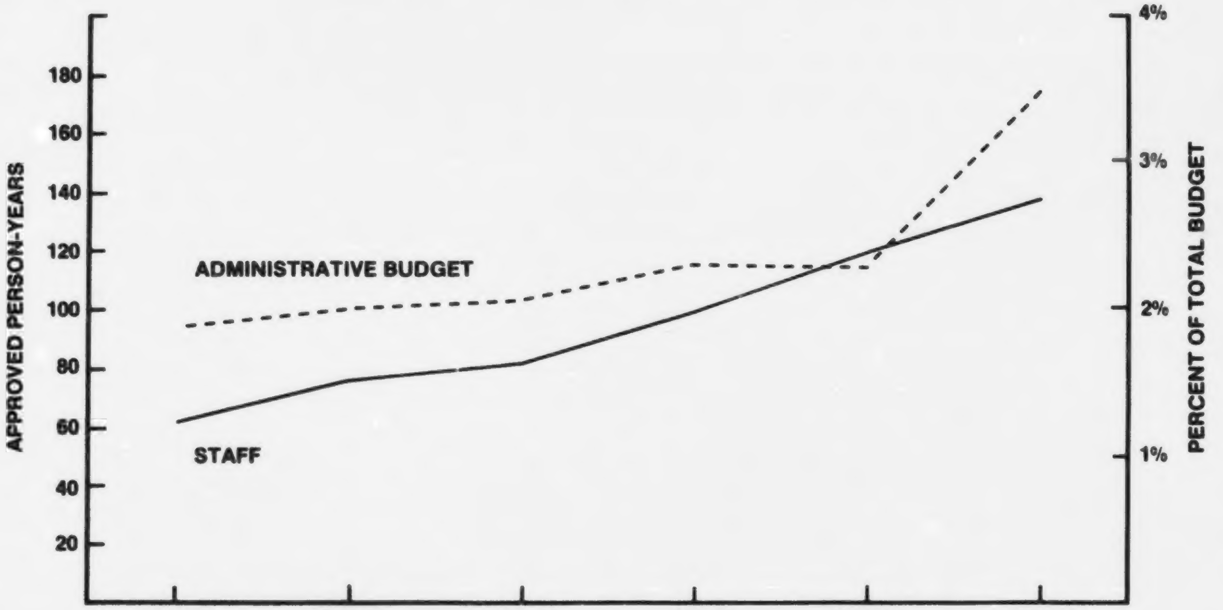
NSERC's initial request for more staff was for the most part rejected by the federal Treasury Board and hence, the first Five-Year Plan addressed this issue head on. In part it said:

> "Taken to the extreme, a granting function can be undertaken by a very few people. The money could be allocated to institutions rather than individuals; no systematic review and audit systems would be pursued; and no efforts made to draw industry and university research endeavours closer together. That is not the type of program the membership of the new Council wishes to be associated with. The challenge of molding and managing a system which reflects the needs of the 1980's has been given to us. The existing programs will not meet that challenge nor will the status quo suffice in terms of management or resources.
>
> NSERC is of the opinion that the programs presented by this submission are essential elements of any new thrust towards greater R&D within Canada. If they are worth doing at all however, they are worth doing well. For example, the greater emphasis placed on targeted research entails a much more management-intensive effort than that associated with programs of free research. If the management needs are not provided, the targeted program should not be undertaken. The interface between industry and university can only be improved by personal contacts, by workshops, and by persistent effort by NSERC staff. Similarly, the increased attention being paid by some provinces to R&D priorities calls for a very significant increase in the level of consultation now carried out. And finally, at a time when "audit" and "control" are the catchwords of government, the resources needed by Council to monitor and critique its programs and to do "research on research" are largely lacking.

Believing that it had a good grasp of the workload associated with the proper management of an expanded program, NSERC proposed to double its staff over the five-year period (65 person years in 1979-80 to 129 in 1984-85). The overall administration budget was to stay in the range of 2% to 2.4% of the total budget. As the programs outlined by the preceding chapters evolved, however, it became clear that the Council had underestimated the pressures on its small staff. The expansion of the former programs, the rapid introduction of targeted and negotiated initiatives, and the more proactive role of the Council in its management style all led to increasing pressures on staff time. Additional staff resources were provided as indicated in Figure 23, but they have not kept pace with the expanding workload. Over the years, NSERC has quite rightly been held in high esteem by the community for its efficiency of operation and quality of service. That reputation and recognition has slipped somewhat over the past two years in spite of excessive overtime and dedicated staff support. Those in the community who understand these pressures continue to express admiration for the work of the Council; however, those who do not recognize the workload and expect efficient personal service are increasingly displeased with the delays that now run up to two to three months.

Figure 23

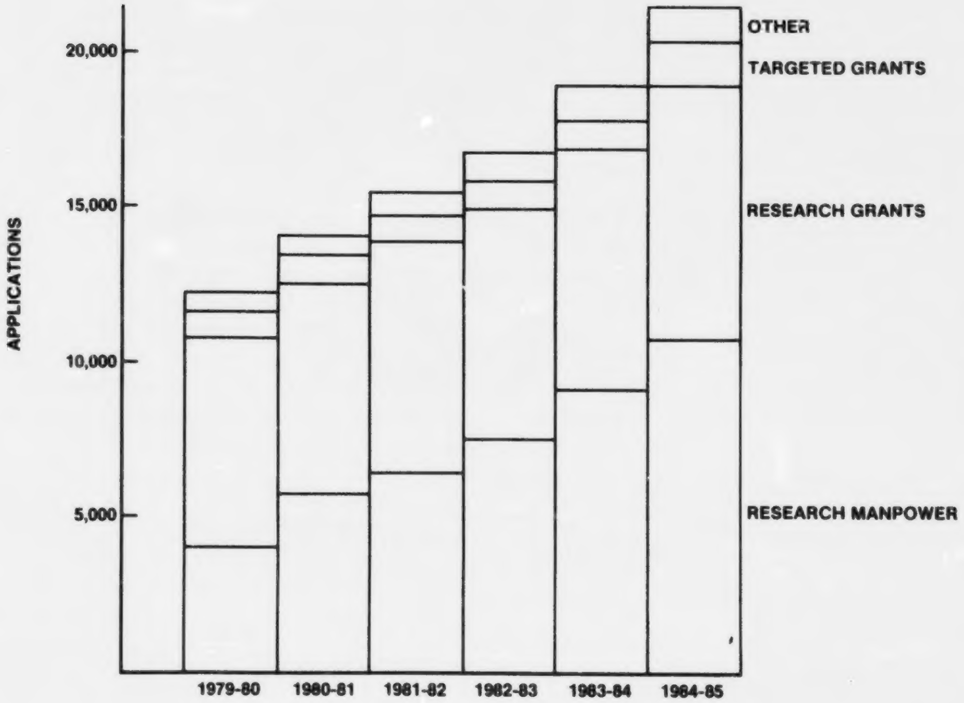
Staff Resources and Administration Expenditures



The reasons for these pressures on staff are many and varied. Some are due to the responsive nature of many of NSERC's programs, so that as interest in research and development increases, so do the demands on NSERC's staff; others are caused by a desire of Council and staff to strive for quality and to emphasize the effectiveness of the granting process, not just its efficiency. Pressures due to "quantity" are illustrated in part in Figure 24, whereas some of the "quality" aspects are discussed below.

Figure 24

Number of Applications for Grants and Scholarships



The Peer Review Process

In the past, 22 grant selection committees met only once a year, during a pressure-packed week in February when they reviewed all the applications for grants; there was little or no time for discussions of policies and procedures or for an after-the-fact analysis of the competition results. Council now arranges policy meetings for all these committees and presents analyses of trends, points of concern, comparisons with other committees etc. The use of external referees to assist in the evaluation of grant applications has also increased. In addition, in 1983-84, a total of 257 visits by committee members to university laboratories were arranged compared to 109 in 1979-80. These visits are essential for the proper working of the peer review process. The 257 visits, together with the visits conducted for other programs and the multitude of committee and Council meetings, mean that NSERC staff are operating a significant travel agency. The cost of committee travel has been a major reason for the increase in the cost of administration; it has grown from $623,000 in 1980-81 to an estimated $1,234,000 in 1984-85.

The Push for Greater Selectivity

As noted in Chapter 4, the Council has been pushing for greater selectivity in the peer review process and has put in place special mechanisms to promote such action. For example, in the 1984-85 Operating Grants competition, 26% of the applicants requesting a renewal of their grants saw them either reduced in value (16%) or terminated (10%). As might be expected, actions like this provoke a considerable reaction from those affected. NSERC staff automatically sent comments to over 750 applicants in 1984-85, but a flood of enquiries, protests and appeals still resulted. All of these letters must be considered seriously and review mechanisms put in place when warranted. Greater selectivity, coupled with fairness and understanding, does not come easily or inexpensively. Over the last two years, the number of letters handled by the Grants and Strategic Grants Directorates has increased by 80% and 85% respectively.

Grant Administration at the Universities

The universities are partners in the granting process. They administer individual awards through common grant accounts and they provide many services in support of research. As noted earlier, the pressure on university budgets is eroding the university's ability to share in the funding of research; it is also eroding in some cases the quality of administrative support. NSERC is increasingly having to deal with such things as lack of selectivity in scholarship nominations or large numbers of incomplete applications of all types. This takes time and effort. In addition, the Council has embarked upon a systematic monitoring of the financial control being exercised by the universities and by the applicants themselves in the use of grant funds. Monitoring visits to the universities and the follow-up to the visits, are very demanding of staff time.

Grant Negotiation

Hidden behind the increasing numbers of applications presented in Figure 24 is the growing complexity of many of the Council's programs. As was noted in the first Five-Year Plan, "a much more management-intensive effort" is now required by NSERC. This effort began with the Strategic Grants program and its test of relevance, and has spread to the University-Industry program with its three-party negotiations. The award of one Industrial Research Chair or one grant in support of a workshop can entail the time and effort associated with the awarding of 100 or more Postgraduate Scholarships. The Council and the government must learn to equate what it is they wish to achieve with the cost of realizing that final product.

Management of Research Manpower Awards

The more the Council offers awards that entail salary support, such as the University Research Fellowships, the more the process becomes labour intensive. Each nomination requires a detailed review to ascertain factors such as research record, citizenship status, salary levels and teaching loads; the views of referees are then sought and, following an award, salary payments must be monitored and a performance review undertaken.

Even a longstanding program like the Postgraduate Scholarships program is not without problems; indeed, with the growth of interdisciplinary research, more and more scholarship candidates find themselves in areas of research that fall between the mandates of the three granting councils. While this trend to interdisciplinary research is desirable, it causes significant workload increases on NSERC staff who must ensure that candidates for awards do not "fall between two stools". A similar challenge exists in the Operating Grants program.

Improved Communications

The expanded number and complexity of NSERC's programs have required an increased communications effort with the university community. The challenge and need, however, go well beyond that community. The increasing emphasis on R&D generally, the push for more effective university-industry interaction and the move to greater federal-provincial collaborative effort all require increased attention to improved communications at all levels. NSERC, through its staff and through Council and committee members, has a good record of consultation and cooperation, a fact that is reflected in provincial support for its programs. However, the current "whenever possible or essential" philosophy will have to give way to a more systematic process in future years and the human resources necessary will have to be forthcoming.

Central Agency Requirements

The growing requirements of the "central agencies" of government are imposing undue pressures on small agencies like NSERC, as these demands are seldom accompanied by the staff resources necessary to do the job. The list of requirements continues to grow and all too often is taking scarce staff time away from actual program delivery.

Summary

Because of the efforts of a highly motivated staff, and an army of volunteer research experts from the universities, government and industry (1), NSERC has been able to operate an increasingly large and complex granting system with overhead costs of less than 3 percent. The allocation of administrative costs is summarized in Table 39. In 1984-85, the 3% level was exceeded for special reasons (2), but it is expected that this level will be realized again in future years. However, this presupposes attainment of the program equilibrium suggested in this second Five-Year Plan. If this is not possible, and if for some reason the more labour intensive programs of the Council come to occupy a larger proportion of the spectrum of NSERC activities, then Council will have to allocate a higher percentage of its total costs to administration. If the funds required for proper administration and the additional person-years associated with them are not forthcoming, then the targeted research efforts and those requiring extensive consultations will have to be reexamined.

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(1) In 1984-85 over 400 individuals worked for NSERC on its peer review committees.

(2) In early 1984-85 NSERC moved from the NRC "campus" and set up a more autonomous operation in downtown Ottawa. Many of the services formerly provided by NRC at favoured rates were thereby lost (e.g. duplication) and fit-up costs for the new space had to be paid. At the same time, NSERC purchased a new computer system and that "one-shot" capital item is covered mainly by the 1984-85 budget.

Table 39

NSERC Administrative Costs
(thousands of constant 1984-85 dollars)

		First Five-Year Plan				
Item	Base Year 1979-80	(1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Salaries and Employee Benefits	2,105	2,455	2,913	3,392	3,695	4,766
Staff Travel, Transportation and Communications	86	147	161	204	189	431
Information and Duplication Services	331	322	389	307	294	613
Professional and Special Services(1)	267	606	650	976	1,049	1,062
Expenditures for Council and Committees	679	921	958	1,297	1,338	1,408
Office Equipment and Furniture	38	174	99	29	149	2,424(2)
Other	48	59	95	180	182	306
Total	3,554	4,684	5,265	6,385	6,896	11,010
Services provided without charge by other good agencies	550	522	522	552	567	604
Totals:						
- constant dollars	4,104	5,206	5,787	6,937	7,563	11,614
- current dollars	2,625	3,719	4,613	6,233	7,107	11,614

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(1) Includes NRC computer fees, computer consultants, program evaluation consultants, and honoraria paid to members of visiting committees to universities.

(2) Includes $1.9 million for the purchase and installation of a new computer and software for the grants and scholarships information system

CHAPTER 10

SUMMARY

NSERC and the community it supports are justifiably proud of what has been accomplished over the past five years. While the overall budget did not meet expectations, and the staccato nature of the funding decisions was hardly conducive to good planning, there has been an effective level of recovery from the previous "decade of decline". There is a general atmosphere of rejuvenation; equipment is more sophisticated and in a much better state of repair; the graduate schools have a much larger complement of Canadian students; and, the truly productive researchers are receiving grants which, while still very modest by international standards, represent real increases over previous levels. Finally, there is encouraging and widespread improvement in the level of cooperation and understanding between the industrial and university communities; a growing recognition that, in this increasingly technological world, their futures are inextricably entwined.

With the funding increases received, the Council has been able to follow closely the priorities identified by the first Five-Year Plan and endorsed by successive governments. However, the process of recovery and growth is by no means complete, and the uncertainty which has prevailed regarding funding for the last year of the first Plan cannot help but raise questions within the research community regarding a long-term commitment to a greater national R&D effort. This hesitation is particularly apparent and worrisome to the young graduates who are seeking clear signals from the government as they approach critical decisions regarding their career paths; they in turn, represent a resource this nation urgently requires in the race for new technologies.

Much has been achieved, but much remains to be done. The products of NSERC's programs, skilled people and new knowledge, are the prerequisites for sustained economic growth. The following sections of this report identify the changing circumstances and challenges and the actions needed to complete "the bridge to the 90s".

SECTION II

A REASSESSMENT

Almost six years have gone by since NSERC developed its first Five-Year Plan. While much has been accomplished since then, new challenges have arisen. This section of the report examines the changed environment in terms of the research and development goals of the federal government, the research talent required to reach those targets, and the deteriorating financial situation of the universities and their laboratories. The following chapters set the context for the second Five-Year Plan and the corrections needed to assure Canada of a strong and innovative research community in the years ahead.

CHAPTER 11

R&D TARGETS: HOW HAVE WE FARED?

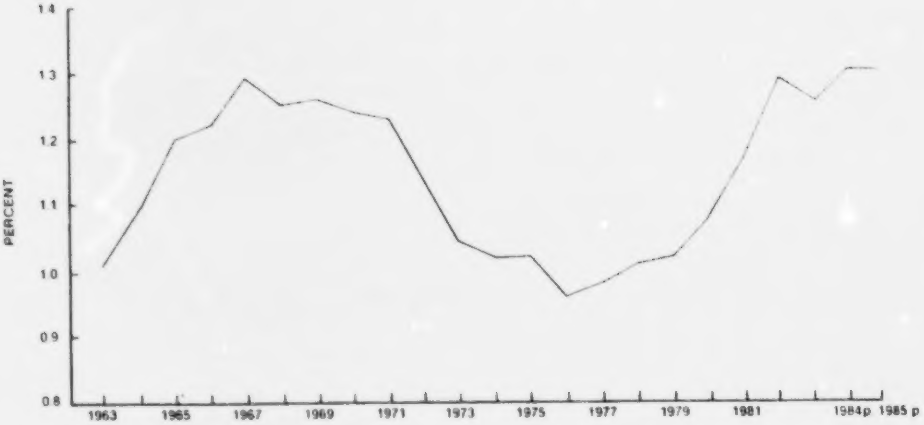
The National Target

By the late 1970s, Canada's overall investment in R&D had fallen well behind that of our western trading competitors; in fact, at a level of 1.0% of GNP(1) in 1979 it was the lowest of any major OECD(2) nation. Without a greater emphasis on research and research training, we faced a bleak future in a world economy increasingly dependent upon advanced technology. The first Five-Year Plan was developed during this period of uncertainty and changing governments. By the time the Plan was implemented in 1980, the federal government had settled on a national GERD (Gross Expenditure on Research and Development) target for Canada's research effort at 1.5% of GNP by 1985. (3) Since it was felt that this goal could be achieved with dedicated effort, the target itself became an effective rallying point for the national effort.

The last six years have brought significant progress. Actual GERD investments doubled from $2.7 billion to $5.3 billion, (4) a real increase after inflation of about 31%. Figure 25 shows how this translates into a significant increase as a percentage of GNP, although clearly the 1.5% target has not been met.

Figure 25

Gross Expenditures on R&D (GERD) as a Percent of GNP



SOURCE: SCIENCE AND TECHNOLOGY STATISTICS DIVISION, STATISTICS CANADA

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(1) Gross National Product

(2) Organization for Economic Cooperation and Development

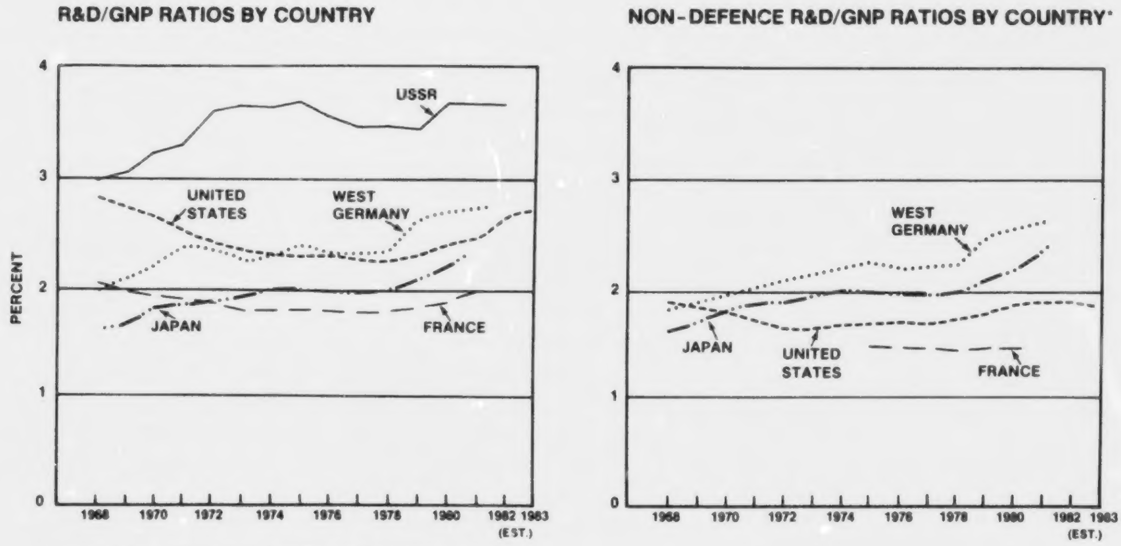
(3) All targets and data relate to expenditures in the natural sciences and engineering

(4) Estimated

While Canada has advanced towards its target, our international competitors have not stood still. Figure 26 presents an estimate of comparable R&D/GNP data for five countries, with and without inclusion of defence-related investments. It should be noted, however, that much defence-sponsored research has major civilian spin-offs. Similar data for Sweden, The Netherlands and Switzerland show R&D investments ranging from 2.0% to 2.5% of GNP.

Figure 26

R&D Expenditures as a Percent of GNP by Country



*SEPARATE DATA FOR NON-DEFENCE R & D IN THE USSR ARE NOT AVAILABLE.

In summary, therefore, to the extent that a GERD/GNP ratio accurately reflects a nation's R&D capacity, Canada has made progress during the past six years, but remains well behind other industrialized nations. Even the argument that "we do more with less" does not compensate for the very real differences in total investment. Canada obviously must intensify its efforts if it hopes to match the competition.

Like the previous plan, the second Five-Year Plan has been prepared during a period of changing governments and growing recognition of the need to expand our national research and development effort. In fact, some policy statements issued during the summer of 1984 pointed specifically to a doubling of the GERD/GNP ratio itself, i.e. from 1.24% to 2.5%. More recently, the financial statement by the Minister of Finance on

November 8, 1984 (1) identified "R&D, Innovation and Technology Diffusion" as the lead item in "A Strategy for Economic Renewal". To quote his challenge:

> "As much as two-thirds of recent economic growth has been attributed to technological change and there is every reason to believe that its influence will grow.
>
> If we are to be competitive, we must become effective in applying leading-edge technologies in producing goods and services. Economic success will stem not only from **producing** technology, but from **using** new technology in established industries, such as car-making, steel production, agriculture, mining and the forest industries.
>
> About 90 per cent of technology used in Canada is imported. Technology adoption, diffusion and the continued free flow of technology across international borders are, therefore, crucial for Canadian industry. Nonetheless, domestically-performed R&D remains important in gaining and maintaining competitiveness in growth industries and in ensuring the speedy adoption of imported know-how."

The foregoing emphasizes, quite correctly, our need for both "domestically-performed R&D" and imported technology. There are some, however, who would argue that we could depend almost totally on foreign technology thereby avoiding the need for large domestic expenditures on R&D; we could select the best and "buy it off the shelf" (conveniently ignoring the fact that the best is seldom put on the shelf). However, even in such a scenario of dismal dependency, this nation would still count heavily on the product of university-based research and development. Without talented individuals trained at the frontiers of science, how could we identify "the best", adapt it to any unique Canadian needs, hopefully improve upon it, and ensure its diffusion and use within Canadian industry? Canada's slowness in applying new technologies within our industries is one of our weaknesses; R&D literacy among managers has to be one of our economic priorities.

For all the reasons noted above, the Council decided to build its next Five-Year Plan around two recent statements of policy, namely:

- there should continue to be a strong mix of domestic R&D and imported technology; and
- there should be a "doubling" of the domestic R&D effort over the next five years.

Given an element of uncertainty as to what exactly was to be "doubled", the analyses considered a number of scenarios:

- doubling the present R&D expenditures **in current dollars;** this equates roughly to a GERD/GNP target of 1.5% by 1990.

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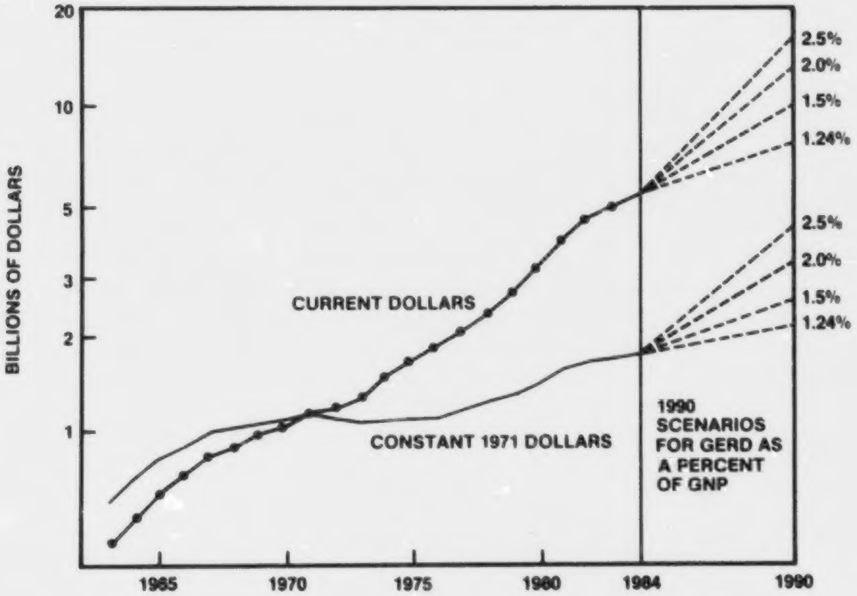
(1) "A New Dimension for Canada: An Agenda for Economic Recovery"

- doubling the present R&D expenditures **in constant dollars**; this equates roughly to a GERD/GNP target of 2.0% by 1990, and
- doubling the GERD/GNP ratio itself to 2.5% by 1990.

The expenditures entailed by each of these options, along with a "status-quo" option (i.e. GERD at 1.24% of GNP) are presented by Figure 27 and Table 40 (note that the vertical axis of Figure 27 is logarithmic). The additional financial resources required are impressive in themselves; they are also effective indicators of large numbers of highly skilled researchers that will be needed to use the funds effectively. That aspect of the challenge is developed in Chapter 12.

Figure 27

Gross Expenditures on R & D in Canada



The Distribution of Effort

The previous national R&D target of 1.5% of GNP set certain expenditure goals for the major economic sectors. (1) While the absolute level of R&D funding by Canadian industry has increased considerably, Table 41 suggests that only modest progress has been made towards increasing the overall **percentage** contribution of that sector.

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(1) Ministry of State for Science and Technology, **R&D Policies, Planning and Programming**, Background Paper, January 13, 1981.

Table 40

Gross Expenditures on R & D in Canada, Related to Economic Activity

YEAR		GNP	GNE Implicit price index (1971 = 100)	GERD (Natural Sciences and Engineering)	GERD 1971 dollars	GERD/GNP
		($ Mill)	(Index)	($ Mill)	($ Mill)	(%)
1963		45,978	74.8	463	619	1.01
1964		50,280	76.6	554	723	1.10
1965		55,364	79.1	665	841	1.20
1966		61,828	82.6	754	913	1.22
1967		66,409	85.9	854	994	1.29
1968		72,586	88.7	910	1,026	1.25
1969		79,815	92.6	1,002	1,082	1.26
1970		85,685	96.9	1,063	1,097	1.24
1971		94,450	100.0	1,160	1,160	1.23
1972		105,234	105.0	1,195	1,138	1.14
1973		123,560	114.6	1,284	1,120	1.04
1974		147,528	132.1	1,504	1,138	1.02
1975		165,343	146.3	1,686	1,152	1.02
1976		191,857	160.3	1,833	1,144	0.96
1977		210,189	172.3	2,055	1,193	0.98
1978		232,211	183.8	2,348	1,278	1.01
1979		264,279	202.7	2,694	1,329	1.02
1980		297,556	225.8	3,204	1,423	1.08
1981		339,797	249.7	3,953	1,587	1.16
1982		358,302	275.5	4,591	1,674	1.28
1983		390,340	290.5	4,969	1,706	1.27
1984		429,500	303.6	5,344	1,745	1.24
1990	scenario (1)	652,083	380.5	8,086	2,125	1.24
1990	scenario (2)	652,083	380.5	9,781	2,571	1.50
1990	scenario (3)	652,083	380.5	13,042	3,428	2.00
1990	scenario (4)	652,083	380.5	16,302	4,284	2.50

Source: Statistics Canada for period 1963-84; GNP is projected to grow at an average annual rate of 7.2% (3.2% volume, 3.8% price), based on the November 1984 Economic Statement by the Minister of Finance.

Scenario:

(1) Steady state: GERD/GNP ratio stays at today's level.

(2) Doubling of 1984 current dollar GERD by 1990: adjusted for inflation, this implies a GERD/GNP ratio of over 1.5%.

(3) Doubling of 1984 dollar GERD in constant dollars: this equates roughly to a GERD/GNP target of 2% by 1990.

(4) Doubling the 1984 GERD/GNP ratio to 2.5% by 1990.

Table 41

GERD Distribution by Funding Sector
(percent of total)

Sector	Actual 1979	Actual 1984	MOSST (1) Target for 1985
Federal Government	36.0	38.1	33.3
Provincial Government	6.8	6.8	6.6
Industry	39.6	40.1	50.0
University	12.2	8.8	7.6
Other	5.4	6.2	2.5
Total	100.0	100.0	100.0
Total GERD:			
- millions of constant 1984-85 dollars	4,035	5,344	
- millions of current dollars	2,694	5,344	

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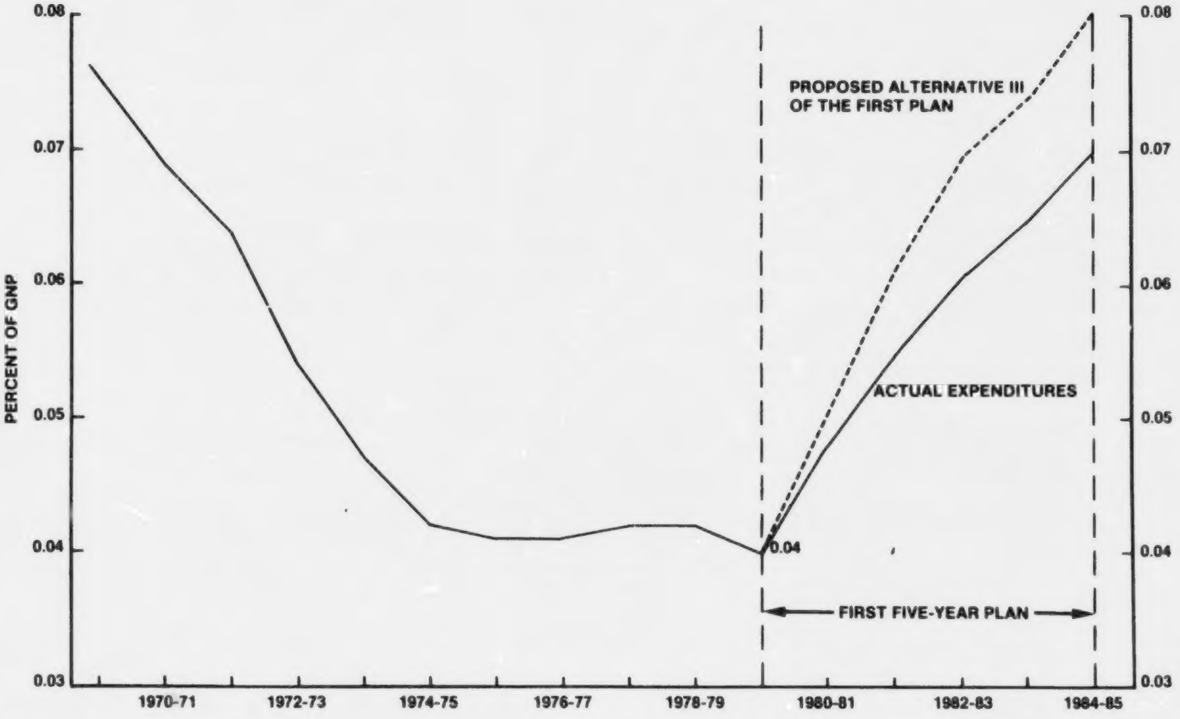
(1) Ministry of State for Science and Technology

Targets were also set within the federal funding contribution itself. Of the increase in federal R&D funding over the period to 1985, 21% was to go towards university-based research. A comparison of 1979 and 1984 funding levels shows that only 14% of the constant dollar increase actually went for that purpose. The difference of seven percentage points translated into a $41 million (in constant 1984-85 dollars) shortfall in 1984 to that sector. In the meantime, the proportion of the federal funding increase that went to industry and, particularly, into federal labs, increased by seven percentage points to 86% rather than the planned 79%.

It is also of interest to look at the funding of NSERC itself as a percentage of GNP. Figure 28 shows the steady relative decline during the 1970s and the recovery brought about through support of the Five-Year Plan. Despite the larger share of university R&D costs now borne by NSERC and the increased dependence on R&D for economic recovery, the Council has yet to regain its position of 1969.

Figure 28

NSERC Program Budget as a Percent of GNP



Finally, a further international comparison highlights our predicament. The following shows university-based R&D funding as a percentage of Gross Domestic Product in 1981 for six countries: (1)

Japan	.36%
United States	.34%
Federal Republic of Germany	.34%
Netherlands	.32%
Norway	.28%
Canada	.24%

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(1) Based on updates to **"OECD Science and Technology Indicators, Resources Devoted to R&D"**, (Paris, 1984)

University Research Funding - Someone Must Accept the Responsibility

There is ample evidence that NSERC is now carrying a much larger share of total university R&D costs. Statements to that effect are being made by the universities themselves, and in many cases any R&D support services that can be billed against NSERC grants are now being charged as a matter of course. The historic sharing of the total cost of university-based R&D is shifting quickly to a larger share by NSERC and a smaller one by the universities.

The major reason for this shift is clear. Figure 29 compares the steady growth in enrolment, and the increased university research and development effort (only partially funded by external sources), to the marginal real increase in the overall operating budgets of Canadian universities. Simply put, universities are being expected to cope with a 50% increase in enrolments and a 50% increase in R&D pressures, with only an 8.5% increase in budget; all relative to 1970. Equally simply stated, they cannot meet both demands. As a result, research and development is suffering as the universities move to support the enrolment levels upon which their provincial operating grants are largely based.

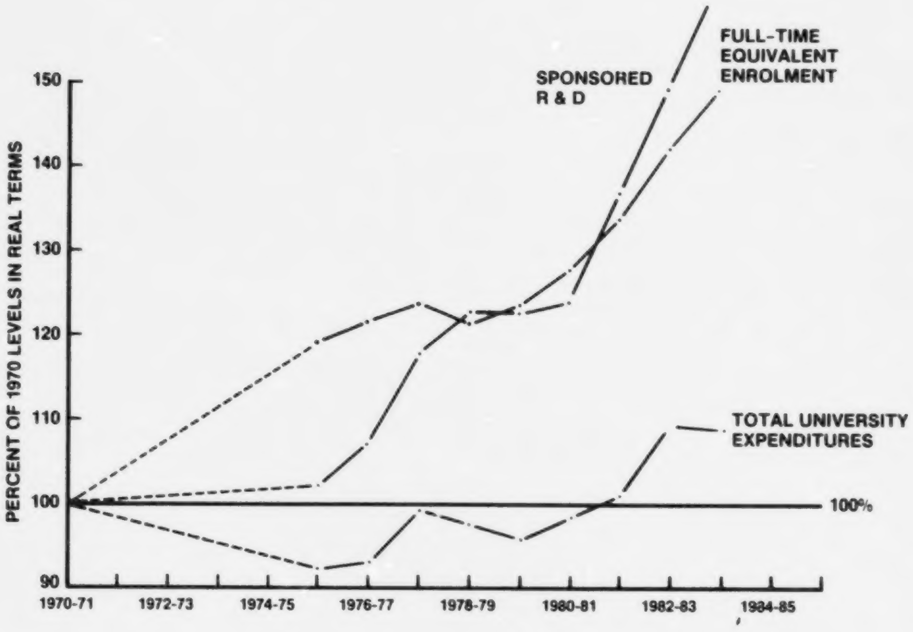
The national averages presented by Figure 29 hide extreme cases. Ontario universities, for example, which receive 43% of NSERC funding, have experienced increased undergraduate enrolments of **59%** and increased R&D pressures of **42%** since 1970. Over that same period, operating budgets, however, have **fallen by 14.5%** in real terms, with universities that are research intensive feeling the greatest pressures.

The current federal-provincial arrangements for the support of university research are thus sadly failing this nation at a time when university-based research and research-training have become critically important for our economic future. An early resolution of the Established Program Financing (EPF) arrangement is urgently needed before irreparable damage is done to the very foundation of our national research effort. NSERC's budget was never intended to fill this ever widening gap in funding, yet that is precisely what is being expected of the Council today; clearly that is impossible under the present circumstances.

The Council itself has not been asked for suggested changes to the existing EPF arrangements nor does it feel it is appropriate to present such proposals. However, if possible new arrangements involve federal government funding of "all" costs of university research, as recommended by the Task Force on Federal Policies and Programs for Technology Development and by the Canadian Manufacturing Association, NSERC urges that it be done in a simple manner that avoids new and large administrative pressures on the universities.

Figure 29

Erosion of the Financial Capacity of Canadian Universities



While everyone waits and hopes for an effective resolution of the EPF issue, the pressure continues to mount to have NSERC's programs fund an increasingly larger portion of the total cost of university-based research. In fact, the second Five-Year Plan itself contains proposals that would move NSERC further into a funding area previously met largely by universities themselves from provincial grants. Great care has been taken to consult with the provinces in the development of these programs and expressions of provincial support have been documented. The Council realizes fully, however, that such initiatives may not be supported by either the provincial or federal governments given the current uncertainties or disagreements on funding responsibilities. However, they represent true and urgent needs and somehow the challenge they represent must be acknowledged and met.

University-based research is too important to be left as a simple adjunct to the total post-secondary education bill, something to which the universities themselves might allocate funds if circumstances permit. The need for research, and research training, must be addressed and funded on its own merits, whatever level of government eventually pursues the issue.

Conclusions

- A major national effort is required to bring Canada's R&D capacity to anything approaching that of our major trading competitors.

- The federal government's in-house R&D effort as a percentage of total R&D activity has increased since 1979 rather than decreased; the expected level of industrial activity has not been realized.

- Federal support of **university-based** research has fallen short of its projected share of incremental R&D funding during the past five years and NSERC's budget increases have failed to bring the level of university support in relation to GNP back to 1969 levels.

- The current federal-provincial arrangement for the support of university-based research is sadly failing this nation. A new arrangement that addresses the specific and vital research role of the universities is required urgently.

The major national effort needed within Canada appears to have been recognized by the federal government. What perhaps is not yet appreciated is the correspondingly large number of highly trained researchers that will be required to use effectively those research and development dollars and to adapt imported technology for maximum national benefit. Chapter 12 presents an assessment of the critical supply-demand equation.

CHAPTER 12

THE HUMAN RESOURCES - ARE THEY ADEQUATE?

The question posed by the title to this chapter really entails five parts:

- are we training enough skilled researchers to achieve our national research and development aspirations?
- is the training adequate and in the right fields?
- once we train our researchers, are we then losing large numbers of this national resource to the United States and other countries?
- can we continue our heavy past dependence on imported research talent?
- can existing research faculty cope with the combination of decreasing budgets and increasing research and teaching demands?

This chapter will address all but the second point. The question of quality is not only relative, but difficult to analyse without an exhaustive study. Furthermore, the establishment of priority areas is a dangerous pastime, past prognostications have usually proven to be very myopic. However, from a review of Section I of this report, one can conclude that the first Five-Year Plan has improved the quality of graduate training in important areas by:

- exposing large numbers of undergraduates to a research environment, thereby preparing them to get the most out of graduate research endeavour;
- greatly updating the quality of the scientific equipment available to graduate students;
- sponsoring a much higher level of industry-relevant research in the graduate schools, thereby making more of the young PhDs immediately productive in an industrial career; and by
- generally improving the whole climate of university research by rescuing it from the despair and decay caused by a decade of underfunding.

For all these reasons, plus the comments received from employers of new PhD and Masters graduates, the Council concludes that high calibre researchers are being produced, although clearly further improvement is always possible. The uncertainty now threatening current standards relates to the funding pressures referred to in Chapter 11 and the displacement of scarce financial support away from the research labs to meet the demands of expanding undergraduate enrolment. The programs to promote graduate study proposed by this second Five- Year Plan can only succeed if accompanied by improved mechanisms to support the overhead and infrastructure costs associated with university research.

The Future and its Demands

The Summary of NSERC's first Five-Year Plan included the following:

> **"The National Need for Trained Researchers:** It is apparent that any major move to improve the national R&D effort is dependent in the last instance on having the qualified personnel to do the work. NSERC has analysed the manpower requirements which are associated with the announced goals for R&D by the mid 1980s as well as the probable production of research trained manpower in the same period. Even with optimistic assumptions regarding postgraduate university enrolment, it is clear that critical shortages of research talent in the 1980s will prevent the attainment of the announced goals."

While NSERC's projections at that time were premised on both an R&D investment target and a GNP growth that failed to materialize, the country still faces shortages in a number of research areas. Had the economic and research funding targets been realized, the human resources available would clearly have been inadequate, notwithstanding the success of NSERC's training initiatives.

The passage of six years has not changed the fundamental problem. Chapter 11 analysed a range of research and development investment options for the next five years and every one of them entails major new demands for research talent. Again we must emphasize that the additional research talent is required even if Canada opts for a policy of greater dependence on imported technology. We would need the specialists if only to select the appropriate technologies, and to effectively employ, modify and improve them.

Canada has no alternative, therefore, but to support the bright young talent emerging from our high schools and undergraduate courses and to prepare them as our future leaders in technology. The questions are then: how many do we need and in what areas?

In the search for answers, NSERC has extensively updated and expanded the manpower supply-demand study of 1979. Some assumptions have had to be made regarding the new R&D investment targets of the federal government. The various scenarios looked at were presented in Figure 27 and Table 40 (pages 120 and 121). They cover all possibilities in the talked about "doubling" of our national R&D effort and range from a "stand pat" investment in terms of percentage of GNP to a doubling of that percentage.

In the analysis of the demand for research talent, NSERC studied a large number of alternatives using various combinations of the following variables:

- real GNP to increase at annual rates from 0% to 3.7% between 1984 and 1990;

- R&D expenditures to stay at 1.24% of GNP or to grow to 1.5%, 2.0% or 2.5% by 1990;

- the relative share of R&D activity among industry, universities and government to remain unchanged or to move to a greater concentration in industry;

- effective expenditure per R&D professional to stay constant or to increase significantly as a result of increased investment in more sophisticated equipment and technical staff; and,

- the average length of the research career of MSc or PhD holders to remain at the historic level of 15 years or to increase to 20 or 25 years.

The supply side of the equation, on the other hand, shows little flexibility. Assumptions were made regarding the percentages of students opting for various levels of graduate study, and the balance of the import and export of talent, but basically the supply of Canadian talent that will become employable during the next five years is already in the undergraduate and graduate schools of Canada. We can hope to improve the percentage of that population that opts for graduate study, but even then the full impact of our efforts will not be felt until after 1990.

Appendix 1 of this report includes a summary of the supply-demand study. The more detailed analysis entitled "Research Talent in the Natural Sciences and Engineering - Supply and Demand Projections to 1990" is available from NSERC upon request. It includes a breakdown of the situation for four discipline groupings and predicts extreme shortages of talent in the applied sciences and engineering and the physical sciences and mathematics disciplines. Within every discipline group, however, one can find serious shortfalls in specific research areas.

Table 42 and Figure 30 present the results of just a few examples of the various scenarios studied by the Council. The conclusion is alarming, even when the use of averages masks the most critical cases. Only under conditions of no economic growth, and no increase in our R&D investment targets, will an adequate supply of research talent be available. **In short, the study shows conclusively that any attempt to increase R&D expenditure as a percentage of GNP (GERD/GNP) will be severely limited by a shortage of skilled manpower.** Furthermore, to achieve any reasonable levels of national R&D literacy during the 1990s, the process of building for that growth must begin now. Figure 31 presents the supply-demand situation for doctorates based on various scenarios.

Table 42

Examples of Annual Supply-Demand Differences for Researchers in the Natural Sciences and Engineering from 1984 to 1990, based on Various Model Simulations (More details in Appendix I)

Real GNP Growth per Year (%)	1990 GERD/GNP Ratio (%)	Distribution of 1990 GERD By Sector(1)	Annual Supply-Demand Difference (Number) Assuming a Research Career length of: 15 Years		20 Years		25 Years	
			MSc	PhD	MSc	PhD	MSc	PhD
0	1.24(2)	1984	453	119	595	231	667	286
0	1.50	1984	160	- 262	302	- 150	374	- 95
1.1	1.50	1984	44	- 414	186	- 302	258	- 247
2.2	2.00	Adjusted	- 756	-1335	- 614	-1223	- 542	-1168
3.2	1.50	1984	- 203	- 734	- 61	- 622	11	- 567
3.2	2.00	Restructured	- 990	-1380	- 848	-1268	- 776	-1213
3.2	2.00	Restructured and increased productivity	- 417	- 519	- 275	- 407	- 203	- 352
3.7	2.50	Restructured	-1820	-2349	-1678	-2237	-1606	-2182

---

(1) 1984: No change from current distribution.
Adjusted: Federal government share falls from 25.2% to 21% of GERD performed; Industry share rises from 50% to 55%.

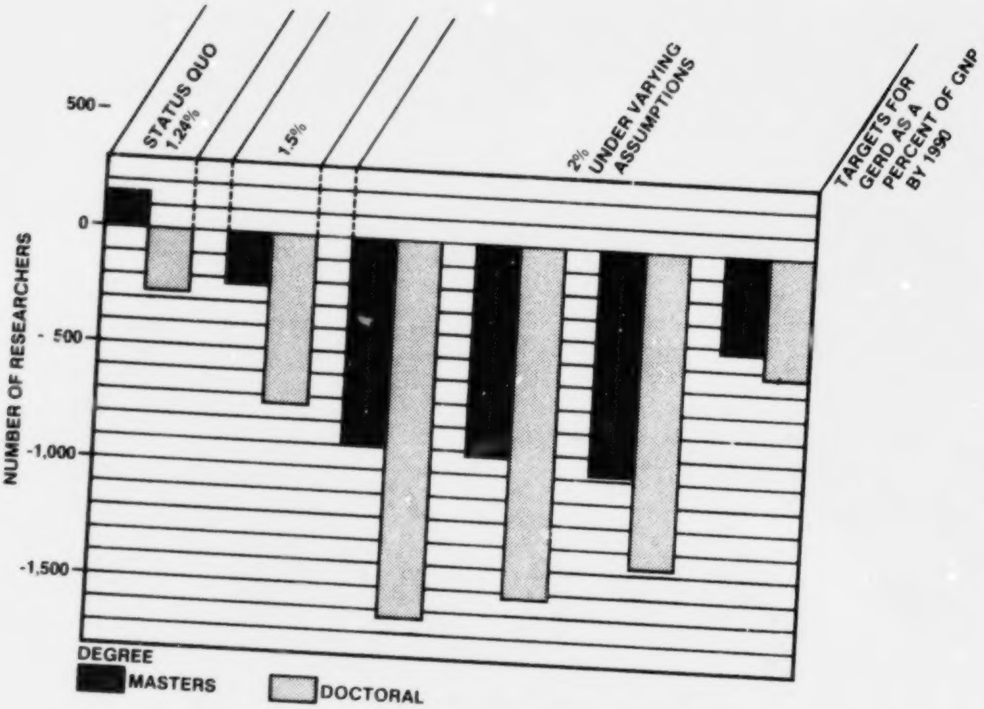
Restructured: Federal government share falls from 25.2% to 12.5% of GERD performed; Industry share rises from 50% to 63.8%.

Restructured and increased productivity: Same as "Restructured", but R&D investment per researcher rises 25% (50% for universities).

(2) Status quo scenario

Figure 30

Projected Annual Shortfalls in the Supply of Research Scientists and Engineers under different GERD Scenarios*



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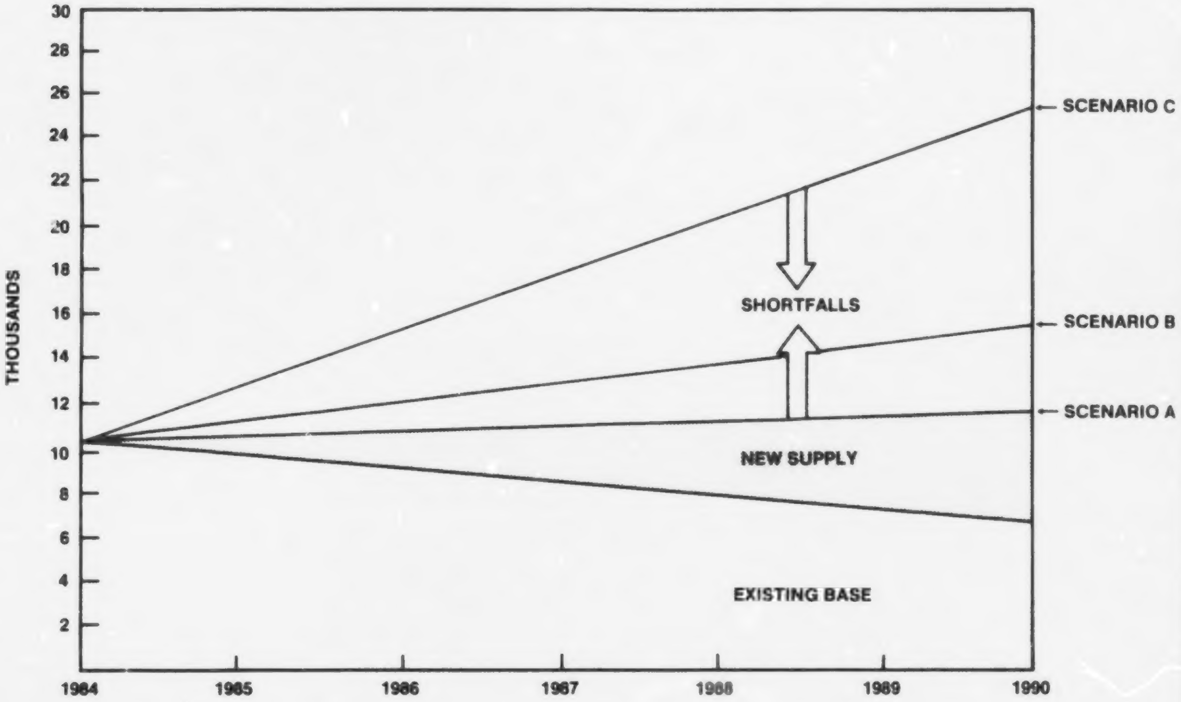
* Assumes 3.2% real GNP growth per year from 1984 to 1990 and an average research career life of 15 years

Figure 31

Cumulative Supply-Demand for PHDs in the Natural Sciences and Engineering, 1984-1990(1)



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(1) Assumptions

Scenario A: 1990 GERD/GNP ratio at 1.24%; "1984" GERD distribution; 0% GNP growth per year; i.e. status quo

Scenario B: 1990 GERD/GNP ratio at 1.5%; "Adjusted" GERD distribution; 2.2% GNP growth per year

Scenario C: 1990 GERD/GNP ratio at 2.5%; "Restructured" GERD distribution; 3.7% GNP growth per year

No amount of quibbling over individual assumptions will alter these disturbing results; if anything, the overall thrust of the analysis tends to understate the problem. Nor is the "import option" a solution. Canada drew heavily on a world supply of talent during the expansion period of the 1960s(1), but that course is not available to us today to anything like the same degree. In current fields of shortage, such as biotechnology, we have to enter a world-wide bidding contest to attract foreign talent and to keep our own talent. In any event, national pride and a critical need for continuity of supply surely force us to attend to the adequacy of our own educational system, although some easing of our policies regarding the retention of foreign students who have obtained their doctorates at Canadian universities might be considered. The United States has recently moved in this direction in response to its pressing needs. Figure 32 shows the relative situation in the two countries and notes the high percentage of all PhD graduates who enter employment in the United States.

Although we are left, therefore, with a challenge that extends into areas well beyond NSERC's influence (e.g. the need for a greater participation of women in the physical sciences and engineering), the contribution of the Council's efforts (Figures 9 and 10, page 18) should not be understated. The total research population has expanded as indicated by Figure 33. The programs of NSERC involved in this process have been evaluated in detail by independent consultants (2) who concluded:

> "NSERC's manpower programs achieve their objectives to a high degree. The programs play an important role in the training and development of highly qualified manpower and have a significant impact on maintaining and assisting R&D activity in this country, both on a short-term and long-term basis".

On the question of a "brain drain" of NSERC-supported graduates the consultants did a similarly extensive analysis and concluded:

> "In the vast majority of cases, NSERC's manpower programs do not produce graduates for export. However, there may be an export problem for those NSERC scholars who pursue graduate studies abroad".

To put the last sentence into perspective, about 10% to 12% of all NSERC scholarships are held abroad. They usually include, however, some of the brightest young researchers. The past loss of 30% to 50% of these individuals could be reduced if there were more faculty positions available in Canada, if the overall research environment in our universities were improved and if Canadian industry could compete with the enticements offered south of the border. As it is, we eventually do recover a significant percentage of the scholars who stay in the United States for postdoctoral studies.

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(1) 51.5% of the 6,621 professors who applied in 1984-85 for NSERC Operating Grants received their Bachelor's degree at a foreign university.

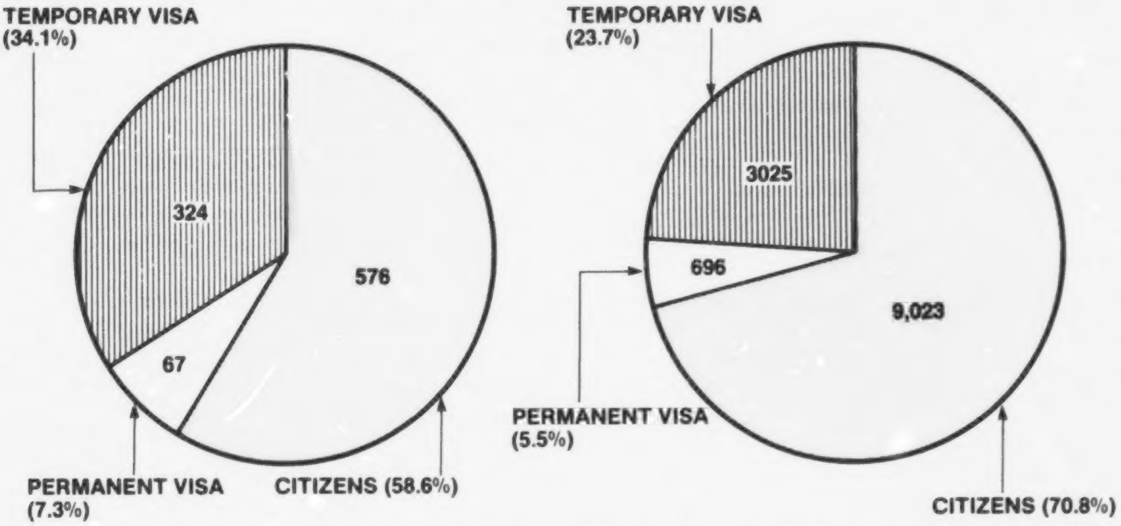
(2) Final Report on the Evaluation of NSERC's Highly Qualified Manpower Programs: Currie, Coopers & Lybrand, January, 1985

Figure 32

Number of Doctorates Granted by Citizenship in Canada and in the United States

Canada
Number of degrees: 967

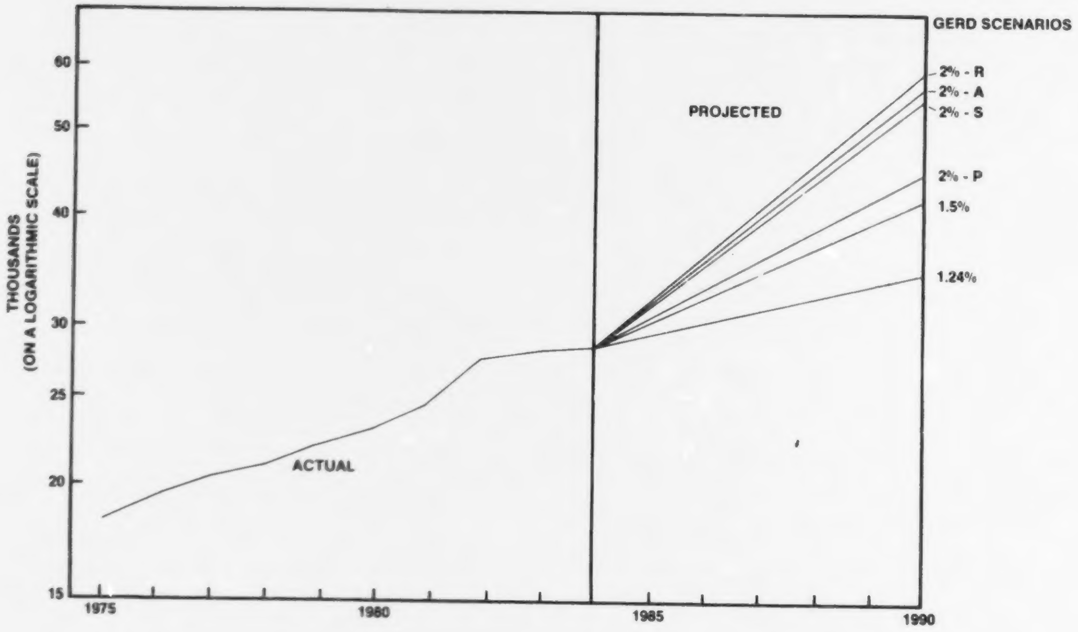
United States
Number of degrees: 12,744



TOTAL NUMBER OF GRADUATES FROM U.S. UNIVERSITIES ENTERING U.S. LABOUR MARKET: 11,342 (89%)

Figure 33

Actual and Projected Number of Researchers (full-time equivalent) in the Natural Sciences and Engineering under Various Scenarios (includes all research sectors and all degree levels)



The research training efforts of NSERC are by no means the total answer to the shortages that have been identified, but they are essential to the overall solution. The extent to which they can be effectively expanded is limited by the population of students available and Section III of this report presents NSERC's best estimate of what can be achieved. **The results that can be hoped for from an expansion of the existing training programs, however, are already reflected in the supply projections that have been presented.** Section III proposes three new initiatives that should help bring some relief to shortages that have been identified. Those should be pursued but, in addition, it is very clear that we must make more efficient use of the research talent already available to us. That issue is addressed next.

The Present Research Force

It is clear that university researchers will be called upon to support and train more and better graduate students. At the same time, they will experience increased teaching loads at the undergraduate level and growing pressure from government and from industry itself for more collaborative research with industry. On top of all of this will be placed university administrative duties as well as calls from NSERC and other agencies to do more and more voluntary peer review work. Somehow amid these demands the researcher must strive to maintain an active research effort.

Not surprisingly, the system is beginning to buckle. The numbers of faculty positions have not kept pace with undergraduate enrolments, much less with the demands for greater R&D and R&D training. Therefore, as we move to build for the future, the needs of the current population of university researchers must be carefully addressed.

To better understand the situation of the researcher, NSERC recently convened a workshop of 19 of its more productive grantees. These individuals were not selected on the basis of the size of their research grants, but rather because, as a group, they appeared to represent that element of the total community which would be under greatest pressure in the years ahead. In other words they are active teachers and researchers, many of whom have strong ties with industry. On average, they manage research programs involving approximately $250,000 a year.

Some of the characteristics of these researchers are:

- their average work week exceeds 60 hours;
- 24% of their time is devoted to graduate and undergraduate instruction and 23% to administration and committee work;
- only 19% of their time is given exclusively to research or research management;
- the average size of the research team supported is 13, including 6 graduate students;
- total NSERC support represents 49% of their total funding;
- salaries and stipends for the research team represent almost 60% of total research expenditures; and,

- their NSERC Operating Grant (on average $70,500) represents in their own estimation their most important source of funding because:

  a) its freedom of use allows them to pursue their most promising and exciting research direction;

  b) it entails a minimum of paperwork; and

  c) it provides continuity of support and thereby continuity of the research team itself.

It is indeed unfortunate that these researchers and their colleagues are experiencing increasing pressures that tend to reduce further their research effort. For example, while one hopes that Canada may eventually develop a university with a research reputation equal to some of the best in the United States, a rather telling statistic is that the student-teacher ratio at the University of Waterloo is double that of Princeton.

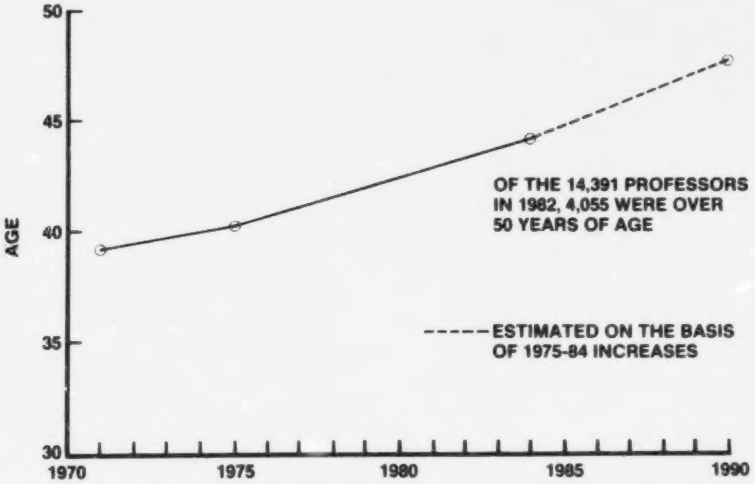
The funding pressures on Canadian universities are eroding both the time for research and the research funding from the university itself. Yet it is this current community of expertise which must maintain its critical contribution to Canada's overall R&D effort and train the greatly increased numbers of new researchers needed for the 1990s.

Finally, one must return to a problem identified by NSERC in 1979: the aging of the current research force, especially those in the university community. The rapid expansion of the universities in the 1960s, and the world-wide recruitment of talent at that time resulted in a population of research professors with a high concentration in a very narrow age grouping. Those professors hired in the 60s are now moving towards retirement in the 1990s. In the meantime, however, the tight university budget situation is preventing the hiring of young faculty to balance the age profile. As a result, the **average age** of the university research force is increasing by 4 years in each 5-year period. Figures 34 and 35 show the overall trend as well as the directions in specific disciplines.

The problem, however, is not just one of eventually replacement of faculty, but also the reduced R&D effort of an aging professoriat. Figures 36(a) and (b) show the extent of this double-barrelled dilemma. Figure 36(a) plots the age profile of all faculty in the natural sciences and engineering and the comparable profile for the segment of that population receiving NSERC Operating Grants. Both show a concentration around the 45-year age bracket (i.e., 20 to 22 years after a bachelors degree) and a growing number approaching retirement age over the next decade.

Figure 34

Median Age of Canadian University Professors in the Natural Sciences and Engineering

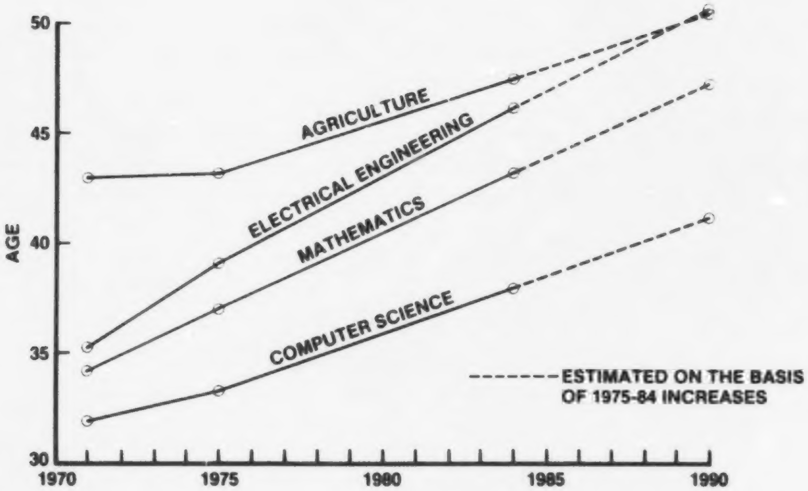


OF THE 14,391 PROFESSORS IN 1982, 4,055 WERE OVER 50 YEARS OF AGE

-----ESTIMATED ON THE BASIS OF 1975-84 INCREASES

Figure 35

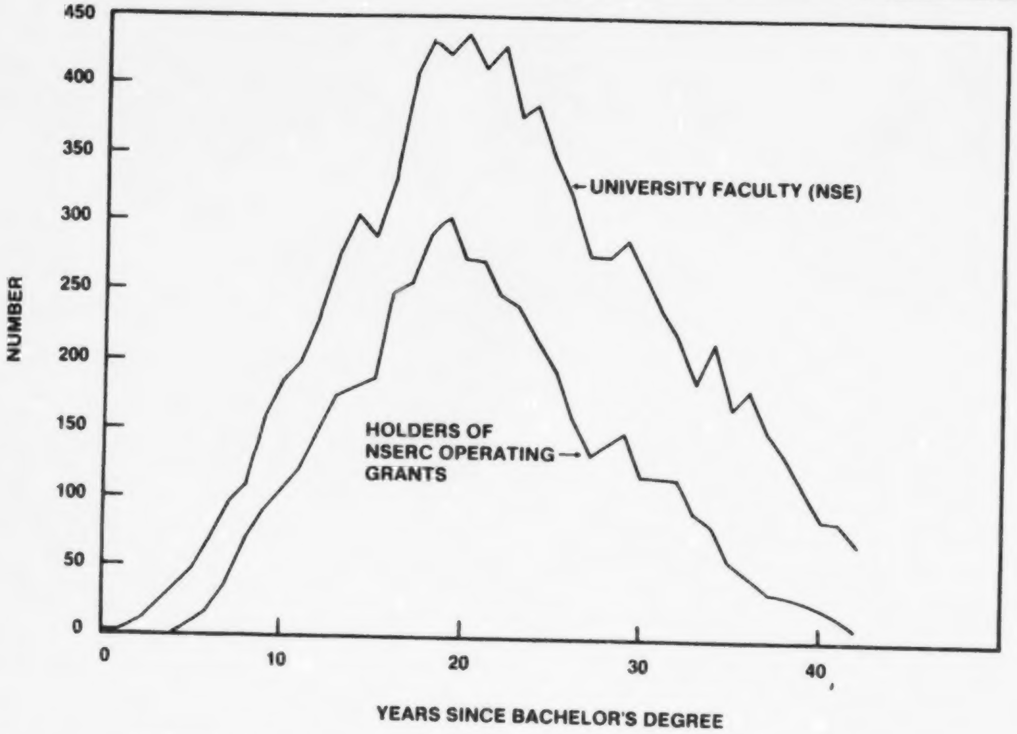
Median Age of Canadian University Professors in Selected Fields



-------ESTIMATED ON THE BASIS OF 1975-84 INCREASES

Figure 36

(a) Number of Faculty and NSERC Grantees by Year Since Bachelor Degree



(b) Proportion of Faculty Receiving NSERC Grants by Year Since Bachelor Degree

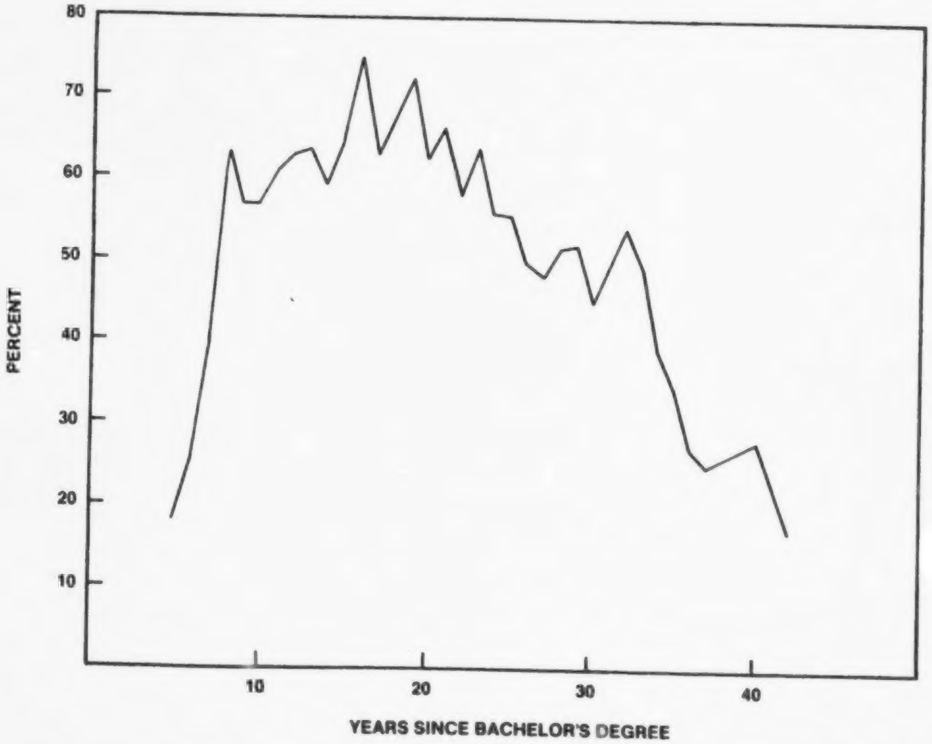


Figure 36(a) also shows that NSERC's research population is drawn from the younger element of the total population. This aspect of the comparison is expressed more clearly in Figure 36(b) which derives the "participation rate" in NSERC's programs (Operating Grants) for the various age brackets. Participation peaks in the period about 18 to 20 years after BSc graduation at 70% and then drops dramatically thereafter, reaching about 25% as retirement age is approached.

Therefore, if current trends persist, Canada faces a major reduction in university-based research effort. A major effort must be made to ensure that professors, as they get older, remain in the research force as active researchers by improving the overall research environment, and by providing up-to-date equipment, adequate technical support, more appropriate operating grants, etc. Also, programs like NSERC's University Research Fellowships are essential to introduce significant numbers of young, research-oriented professors into the academic community over the next decade. However, even though NSERC is a world-leader in that type of initiative, its contribution is still modest given the magnitude of the problem. For this reason, expanded efforts are required to:

- improve the productivity of existing researchers by providing them with better infrastructure support; and

- augment the current research force through the support of new research teams that are of high quality and provide a good mix of young and established research talent.

The Research Professorship program proposed in Section III (Chapter 15) represents NSERC's response to the second challenge and to that of creating groups of critical mass in some of the rapidly emerging and important research fields.

Summary

Skilled human resources, as one would expect, will be increasingly important as Canada strives to develop a growing and more balanced economy in a competitive technological world. NSERC's manpower supply-demand analysis that:

- the research talent required to achieve a competitive level of R&D performance in this decade is not available;

- our past reliance on imported talent is no longer an easy option, nor is it consistent with assuring a dependable supply of skills;

- serious financial pressures inhibit the most effective use of existing research talent; moreover, given the aging of the research population, we will have difficulty in maintaining the existing research capacity. We must also prepare for a massive replacement task during the 1990s;

- educators at the secondary and post-secondary school levels must promote a greater interest in the natural sciences and engineering, especially in the physical sciences and engineering and especially by women;

- NSERC's programs over the past five years have played an important role in the development of more research talent and must be continued and expanded; and

- new initiatives are called for to retain research talent in Canada, to help minimize the shortage of research talent and to create the critical mass of interdisciplinary study so essential in many emerging research fields.

CHAPTER 13

THE RESEARCH ENVIRONMENT

As noted earlier, the various programs of NSERC are strongly interdependent. Overall, the Council is striving to develop a stimulating research environment that will attract more and more young Canadians to a career in R & D. This goal can only be met if our best researchers are well funded and if they are provided with state-of-the-art equipment and a level of technical and support services that will permit them to do research rather than patching, mending and servicing.

Given the extent of the decay and disillusionment that prevailed during the 1970s, the road to recovery has been difficult. The present health of the patient can be summarized as "improved, but vulnerable to a relapse". There is no doubt that the research environment has benefitted greatly from the increased government funding of NSERC, although the irregular nature and timing of those increases have, on occasion, destroyed any sense of continuity.

However, having made reasonable gains over the past half decade, the university research community faces serious obstacles as it moves towards the '90s. Most of these have already been mentioned. They are:

- decreased research funding from the universities' own resources;
- uncertainty regarding NSERC funding levels;
- emergence of research challenges that are extremely costly to pursue;
- increased teaching loads; and
- an aging professoriate.

By the same token, there are many opportunities:

- a new awareness by industry and governments of the vital importance of fundamental research at the universities;
- a concomitant awareness by industry and by the universities of their interdependence and of the need for collaboration;
- exciting new fields of endeavour where the concentration of Canadian expertise resides in the universities, e.g. biotechnology, artificial intelligence, surface science, etc; and

- clear indications that, if opportunities and funding are available, some of the talent that has left this country will return to complement our existing resources.

With this as background, we now look at the challenges and opportunities facing the Council's three major granting programs over the next five years.

Discipline Research: The Operating Grants Program

As noted in Chapter 4, this program lies at the heart of all NSERC's efforts. If researchers perform well, Operating Grants provide them with a stable source of funding that assures continuity of their research teams and projects and guarantees a secure base upon which they can undertake short-term research contracts for industry and government. NSERC Operating Grants allow the researcher complete freedom from outside research direction. This vote of confidence in able, inquiring minds stems from Council's conviction that most of the great advances in science have come through the efforts and intuition of individuals, not by predetermined or directed research priorities developed and imposed by "outside managers". This element of freedom sets these grants apart from those of most other programs in Canada or abroad, and has also made them the envy of researchers in other systems. NSERC has reviewed the merits of this approach and has concluded that it must be maintained as the Council's top priority.

This expression of confidence in the individual, however, brings with it special responsibilities for Council and for grant recipients. Accordingly, some changes have been made over the past five years and others are being explored. For example:

- the Council has adopted more broadly defined and appropriate criteria for the review of applications from engineers. These criteria reward achievements of industrial significance and interaction with the user community;

- the Council makes special budget allocations to ensure that the approximately 450 professors who each year apply to NSERC for the first time have a reasonable opportunity to establish their research careers;

- the Council has promoted rigorous selectivity in reviewing applications from the established research community. The policy rewards excellence and phases out support for less productive grantees. In the 1984-85 competition, 10% of applications for renewal of grants were rejected and another 16% were reduced in grant value. This ability to prune and rejuvenate the overall effort is, in itself, fairly unique to the university granting system where a research effort is not necessarily a prerequisite for employment. However given the importance placed by the community on the value of one's Operating Grant, the rejection of former grantees is taken only after very careful review.

- the peer review system, which now comprises 19 discipline review groups, has been carefully overhauled. Increased numbers of site visits and annual policy sessions have made these review groups more aware of the merits of individual research efforts and more responsive to the general policies of the Council itself. However, compartmentalization of the system by discipline or discipline group, is itself becoming a problem. Increasingly, research efforts are reaching beyond the traditional limits of any one discipline and more and more applications are testing the limits of flexibility and competence of the various peer committees.

While an interdisciplinary grant selection committee exists, and greater use is being made of it, the trend is such that restructuring of the review process may be necessary.

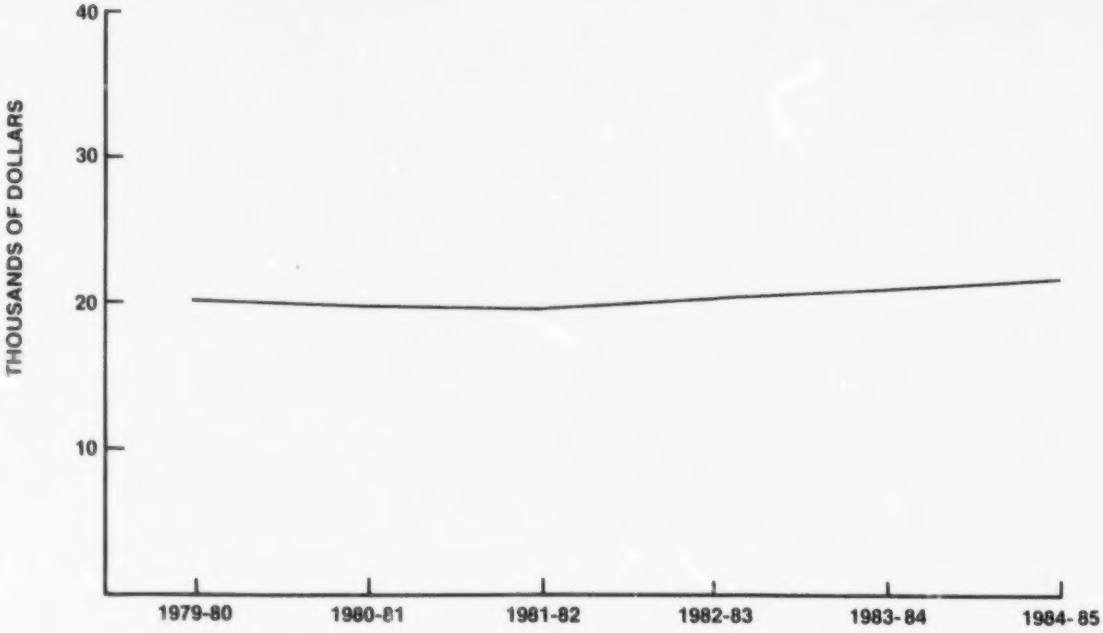
When all the considerations are taken into account, the overriding concerns facing NSERC's Operating Grants program over the next five years are:

- adequacy of funding; and,
- the need to concentrate resources and to build the critical mass so important for many of the new, interdisciplinary research areas.

It is only fair to note that the Council's recent emphasis on equipment, manpower training and targeted grants has not brought equal benefits to researchers in all disciplines or to individuals within a discipline. Even for those who have applied successfully to these new or expanded programs, the need for a stronger base of Operating Grants is clearly evident. Figure 37 presents the average grant (in 1984-95 dollars) in each year for those grantees who received an Individual Operating Grant. The Figure shows that the average operating grant has remained practically unchanged despite increased financial pressures and demands.

Figure 37

Average Value of Individual Operating Grants



The average Individual Operating Grant in 1984-85 was $21,857; the comparable award in 1979-80 was $20,017 (in constant 1984-85 dollars) so there has been a real growth of 9% over the past five years. The value of the award in 1969-70, however, was $24,875 (in constant 1984-85 dollars) so the average researcher today is working with a grant 14% smaller in real terms than that of 15 years ago. A number of factors combine to reduce further the grant's effective spending power:

- universities now charge grantees for many services that used to be free of charge as part of the institution's contribution to the research effort;

- in many fields, costs of doing research are increasing faster than general inflationary trends, (due for example, to improved guidelines and controls for dangerous chemicals or the care of laboratory animals, northern travel costs, expanded computer use, etc.);

- many advanced research programs, particularly in fields such as biotechnology and surface science, are significantly more costly than the average program of the past. This added "sophistication factor" includes the cost of full-time technical or professional assistants, expensive supplies (e.g. restriction enzymes and chemicals which cost between $10,000 and $25,000 a year) and a wide variety of specialized research equipment;

- researchers are supporting an increasing population of graduate students. While of assistance to the researcher, graduate students bring with them the need for salary (stipend) support (if the students are not on NSERC scholarships), and supplies. Figures 9 and 10 on page 18 indicate there are double the number of masters students enrolled today than in 1972-73 (11,000 vs. 5,500);

- finally, increased funding for targeted research and university-industry activities is, in theory, over and above Operating Grants; in practice, however, this targeted effort imposes increased pressures on Operating Grants, which must provide for the ongoing technical support and for the maintenance and operation of the basic laboratory equipment.

All of the above illustrates the inadequacy of an average Operating Grant that has less spending power than that of fifteen years ago. The average award of $21,857 does not meet the reasonable needs of the researchers, the expectations of the funders, and the national objectives for R & D growth. The Council will continue its push for even greater selectivity, thereby increasing the average award by decreasing the number of grantees; however, there is a point where this pruning becomes destructive. University faculty are already a "pre-selected" group given their education and the screening process they have had to pass through to achieve a university posting. NSERC's peer review process makes an additional assessment of their research productivity. It is safe to say that the roughly 60% of the science and engineering faculty who meet NSERC's standards are all capable of good research and most support graduate students in their training program. NSERC's ongoing process of selectivity, which screens out about 10% of those researchers applying for renewals each year, attempts therefore to distinguish between productive and very productive and is at a point where productive researchers are being rejected. There is obviously a limit to how much the value of the average grant can be increased via that process without undermining the base of research competence and research training in this country.

The obvious question then arises; What is an "adequate" average Operating Grant for a productive researcher? NSERC would not apply added funds on an averaging basis, but for the sake of simplicity of presentation, the following is suggested:

- 1 to 2 research professionals, postdoctoral fellows or technicians ($36,000);

- 1 to 2 graduate students ($15,000);

- minor equipment purchase and maintenance ($7,000);

- routine supplies for a 4-person team ($10,000);

- travel, publication and other costs ($2,000).

This totals $70,000 a year, which is more than three times the average grant awarded in 1984 and which can be compared to a cost of at least $100,000 a year to support the work of a professional researcher in industry or government ($150,000 to $200,000 if all costs, e.g. salary, laboratory space, etc. are included). Even at $70,000 a year, a university researcher would have to seek contract funds, grants from NSERC's targeted programs and private funds to support a nationally or internationally competitive program. NSERC's average grant of $21,857, however, translates into no full-time professional or technical staff and perhaps a part-time graduate student. Given the objective of "doubling" our national R&D output, and the training effort that is a **prerequisite** to attaining that target, there is no doubt that a significant increase in the overall funding is required over the next five years. Equally clear, however, is the fact that the increase must be allocated selectively to productivity and excellence. The Council does not support automatic research grants for all faculty; that is an invitation to mediocrity.

Two final comments are warranted. First, Table 14 on page 45 presents the recent history of "first-time" applicants for Operating Grants. The number of such applications seems to have peaked and is currently at about 450 a year. Behind the numbers, however, is a significant improvement in overall quality which warrants a correspondingly high success rate in the competition for funds. The increase in quality is understandable; some of the applicants have succeeded in NSERC's tough competition for University Research Fellowships and some are well established researchers moving back to Canadian universities. For the most part, they represent the new young faculty that are so essential for the overall health and continuity of the research effort. Given the very few faculty positions available today, more emphasis is being placed by the universities on research competence in the selection process. The budget of the Operating Grants program must reflect this increased quality and productivity over the next five years.

The last point relates to a pressing need in many research endeavours to concentrate resources to attain the critical mass essential for a truly competitive national effort. The Research Professorship program presented in Section III is one move in this direction, but this concentration must also be reflected in the largest program of the Council, that of Operating Grants. To some extent, a system of grants to individuals works against collaboration, although much collective work is done. Over the next five years, the Council must find better ways to support collective efforts while not negating the intrinsic freedom of the granting system. Where the research effort is centred around major facilities, researchers may have to change employment location or become increasingly mobile. (The "suitcase" life of a number of high energy physicists is a well established example). In some fields, researchers may be able to work from a remote location through networking and electronic data transmittal. If this re-adjustment is to succeed, however, the researchers themselves must see the need and merit of interactive research efforts. NSERC's programs will encourage them to move in that direction.

Research Equipment and Infrastructure

Purchase of Equipment: Chapter 3 has already reported on the equipment obsolescence problem that faced NSERC in 1979 and the high priority given to a resolution of that problem over the past five years. During the five years, 26% of all new funding went towards the Equipment Grants programs for a total of $110 million (constant 1984-85 dollars).

While considerable corrective action has been taken, the legitimate and urgent needs of the community have by no means been met and the steady growth in applications shows no sign of levelling off. This should not be surprising, the 1981 Task Force (1) set the need at $80 to $90 million (in today's dollars) a year, well beyond NSERC's contribution to date. Furthermore, the rate of obsolescence of equipment is accelerating at a pace unheard of even a decade ago. Competitive research programs and top quality research training demand state-of-the-art equipment; asking a highly skilled researcher to compete internationally with technology that is 10, 15 or 20 years old is like asking a mechanic to repair a late model car with a set of non-metric wrenches.

While the need for new equipment continues, there are encouraging signs that more Canadian content is being built into equipment purchased from NSERC grants. An analysis of the Major Equipment and Major Installation requests in the February 1985 competition shows potential Canadian content in the range of 25% to 30%. There is good reason to expect further improvement as small Canadian manufacturers expand and multi-nationals set up Canadian operations. The fledgling Canadian companies are nonetheless heavily dependent upon sales to NSERC grant recipients and, in some cases, for the development or refinement of some of their products. Any gaps in NSERC funding would set back their growth.

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(1) Report of the Task Force on Research Equipment to the President of the Natural Sciences and Engineering Research Council, May, 1981.

Equally encouraging is the fact that more facilities now enjoy multi-discipline and even multi-sector use. An ever widening community is using these new facilities, especially those purchased through Major Equipment and Major Installation awards (i.e., awards greater than $125,000 each). Since NSERC's policies favour a multi-user, multi-university approach, this trend is not unexpected. Moreover, in the February, 1985 competitions, which contained almost 200 major requests, **over 60% of the applicants suggested significant potential for interaction with local industry.** That trend should also strengthen as the two communities work closer together.

Infrastructure: While the term "infrastructure" is sometimes used to include capital equipment, its use here relates only to the operation and servicing of that equipment and to the cost of the increasing number of specialized technicians needed to sustain a modern research activity. Chapter 3 looked at NSERC's past funding in this area (pages 37 and 38). It concluded that "the need...is out of all proportion to existing levels of funding".

Realizing that the demand for support greatly exceeds the Council's rather modest efforts, NSERC commissioned a Task Force study of the problem. Even here, however, the total need was not addressed; the Task Force was asked only to identify research infrastructure needs (i.e. maintenance, operation, and technical support services) for specialized equipment used **in common** by a number of faculty researchers and their associates. Many of the support services required by individual researchers therefore were not included in the assessment.

The Executive Summary of the Task Force report (1) is included in Appendix II and the complete document is available upon request. The main conclusions are the following:

- the problem is severe and is growing as limited university budgets are moved more and more away from research towards undergraduate support;
- the problem is particularly serious at research-intensive universities;
- the problem is concentrated in newer research areas, e.g. computer science, that did not benefit from the significant university research support built up in the sixties and early seventies;
- the problem is particularly severe in some provinces, e.g. Ontario;
- university researchers are attempting to work with only a fraction of the technical support normally available in government and industrial laboratories;
- there is an immediate need for an additional annual investment of $48 million (constant 1984-85 dollars) for research infrastructure services;

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(1) Report of the Task Force on Research Infrastructure to the Natural Sciences and Engineering Research Council, Ottawa, August, 1984.

- most of the new funds should be allocated to departments and universities through block grants based on the level of other NSERC awards going to researchers at each university; and

- that level of investment is estimated to provide employment for some 1200 people.

The Council has endorsed the Task Force's assessment of need, but not the recommended mechanism for funding. In that regard, further studies are being done to develop the fairest inter- and intra-university distribution. Furthermore, NSERC recognizes that much of the infrastructure needs identified used to be provided, in part at least, by the universities themselves. The question therefore arises: Why should a federal government agency pick up the slack caused by an erosion of other sources of support? NSERC's view is that it has the responsibility to note the destructive lack of support, to quantify the need and to propose funding. While it is just one small part of the whole question of federal-provincial arrangements for post-secondary education, Council has included it within proposals for the next Five-Year Plan to stress its urgency. Whether the needs are ultimately met by NSERC or another agency is immaterial, as long as they are met. Hopefully, the matter will be resolved in the broader federal-provincial negotiations, but clearly it must be resolved soon or the whole structure of university-based research will suffer.

The Targeted Programs

Chapter 5 has given a comprehensive update and analysis of the Strategic Grants program and the various University-Industry initiatives. The success of these programs may, in fact, be their greatest "problem". Having promoted this type of activity against early resistance, Council is now reaching the unfortunate position of lacking adequate funds to respond to all good research applications. That was the case in the Strategic Grants program in 1984-85 (26% success rate in funding) and that will probably be repeated for University-Industry initiatives in 1985-86 unless there is significant budget growth. It is sometimes difficult to interest busy researchers to embark upon new and complex research programs; it will be even more difficult to rekindle their interest if they spend considerable time preparing excellent proposals, which are then turned down for lack of adequate funding.

The Strategic Grants program is generally healthy, although there has been a significant reaction to the low success rate in 1984-85. Improvements can and will be made, however. Study groups are currently assessing such questions as:

- Is adequate support given to groups who have excellent research records, but whose research areas are not directly relevant to their new Strategic Grant proposal? In other words, should the selection panels show a greater willingness to accept risk in order to build greater competence in identified strategic areas such as biotechnology?

- At the other end of the spectrum, to what extent should Strategic Grants extend into demonstration and development? Should that part of the effort be left to the mercy of federal programs requiring an industrial partner? What if there is no "industry" in this area yet?

- To what extent should very fundamental work be supported, especially if economic or other benefits could be many years away? And,

- What processes can be pursued to produce a better follow-up on final reports? What user communities should see those final reports?

The answers to these questions may not be found within the Strategic Grants program itself, but rather through a better integration of all NSERC's initiatives. But they are healthy questions and show that the program and its administration are not static and inflexible. Improvement is always possible, but there is no doubt in the Council's mind that this program is worthy of both retention and expansion.

With regard to university-industry collaboration, NSERC feels it is in a unique position to strengthen the bridge between these communities. The Council is not viewed as a competitor for research funds by either sector, but rather as a facilitator. In addition, the Council's knowledge of the university research community and of the areas where effective cooperation is likely to be most productive, promotes effective use of time, scarce research talent and money. The policy adopted by Council mirrors the views expressed by a university researcher to the effect that university-industry cooperation develops slowly and depends on a close personal relationship that must be worked out by both partners; "NSERC might be the lubricant, but should not expect to be the glue".

It is encouraging to read endorsements from non-academic quarters for NSERC's insistence on a peer review process for the University-Industry program.(1) This assessment procedure occasionally draws criticism from elements of the university community itself, but NSERC will continue to use it and to insist that money should not be spent just because the objective of an application is attractive; sound research and capable researchers must be involved.

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(1) Report of the Task Force on Federal Policies and Programs for Technology Development

In summary, then, while less than a year's experience with the expanded University-Industry initiatives is hardly adequate to reach firm conclusions on the program's success, there is every indication that NSERC's flexible approach is just what was required to transform the latent desire for cooperation by these two communities. The Council recognizes, however, that there are limits to both the rapidity and the degree of cooperation such special programs can bring. Attitudes are slow to change on both sides; other programs of support exist, albeit with different mechanisms; and there is a clear limit to the percentage of university-based effort that **should** be driven by today's perceived industrial needs. Accordingly, the projections for growth in the next Five-Year Plan are gradual rather than extreme. The University-Industry program should build on successes and new associations of researchers rather than being force-fed.

Summary

The research environment upon which NSERC must launch its next Five-Year Plan is much improved over that of 1979. There are, however, significant weaknesses that must be addressed and corrected during the rest of this decade. They are the following:

- Operating Grants, the fundamental sustaining force for all other programs, have not been major beneficiaries of the increased funding over the last five years. The average grant is only a small fraction of what it should be, and yet it is being called upon to meet a multitude of new demands;

- A greater concentration of resources is needed to produce the critical mass required in many new and exciting research areas. This effort also depends largely upon adequate Operating Grant support; equipment and infrastructure funding will also play a large role;

- Equipment renewal, which was progressing well, has by no means been completed. This is an ongoing challenge of increasing importance if competitive and efficient research and research training is expected;

- There is a growing need for a broad range of infrastructure support as university funding moves away from research to undergraduate teaching pressures. This widening gap must be closed, if not by NSERC then by some new federal-provincial arrangement that recognizes the specific needs; and

- NSERC's programs of Strategic Grants and University-Industry initiatives need increased funding to support the truly excellent proposals that are forthcoming and to build on the mutual understanding and respect that is developing within the two research communities.

Encouraged by the progress of the past, we now turn to the Second Five-Year Plan.

SECTION III

COMPLETING THE BRIDGE TO THE 90s: NSERC'S SECOND FIVE-YEAR PLAN

CHAPTER 14

THE FRAMEWORK

NSERC embarked upon the planning of its second Five-Year Plan with no preconceived notions about the role the Council might play in the national R&D mosaic. Council instead undertook a step-by-step analysis of the success of its existing programs to determine whether they should be continued or whether new ones are required, and then developed an interdependent network of activities to meet, to the extent possible, the urgent research and research training requirements of Canada. This second Five-Year Plan, therefore, is a response by this "arms-length" granting agency to the federal government's R&D targets. It documents how the programs of the Council must be strengthened to meet, or at least approach, those objectives.

Given the wide gap between the government's expectations for R&D, and the practical reality documented herein, it would be all too easy to seize upon this analysis as an excuse to throw up one's hands and do nothing. Clearly that would be a mistake. The goals themselves are reasonable. The shortage of intellectual capital, if not financial capital, only means that it will take longer to meet those goals than originally contemplated. Furthermore, the path ahead is now clear; this nation must strengthen its total educational system and the training process leading to careers in the natural sciences and engineering. Provincial governments must respond to that need and federal-provincial funding arrangements reflect it. Within areas of federal jurisdiction and opportunity, an absolute priority must be placed on the graduate training of our research leaders of tomorrow and the promotion of greater university-industry collaboration in research. In essence, the whole structure of university research endeavour must be strengthened and it must be given the continuity of support so essential for sustained effort.

NSERC's programs are by no means the full answer to the challenges we face, but they are the foundation upon which that total effort must be based. Today, that foundation is not adequate for the task and it is being weakened further by the combination of reduced support from the funding partner, the universities, and by the history of hesitant and fragmented support of NSERC itself. The first of these challenges can only be overcome by a successful and effective resolution of the current federal-provincial arrangement for support of postsecondary education and research; this document has had to assume that that will happen. It must be accompanied, however, by a positive response to this second Five-Year Plan.

Before we look ahead, however, the starting point in terms of funding must be clarified. The current situation is both confusing and unsatisfactory. First of all we must note that the $20 million funding increase provided to NSERC for the fifth year of its first Five-Year Plan was not approved as an ongoing commitment. It was a "one-shot" increment provided late in the fiscal year to meet some of the university community's urgent need for equipment. Accordingly, that $20 million disappeared from NSERC's budget on April 1, 1985 as did the $13.7 million two-year increment provided in 1983 (See Figure 2, page 6).

The second Five-Year Plan thus has to start with corrective action; action that is absolutely essential to give continuity to the investments made by NSERC in 1984-85 and to put the second five-year effort on a firm footing. By mid-January 1985, the Council had already had to commit a major portion of its 1985-86 budget; it did so in the belief that its request for a funding increment in 1984-85 of $24.6 million would be forthcoming and that that increase would become an ongoing part of its budget. The only other option available to Council was to assume that those increases would not be forthcoming, and to start to cut back on its awards, i.e. fewer scholarships and fewer research grants. Given the federal government's repeated references to an increased R&D investment, and the urgent need to maintain continuity of effort in research and research training, that second option had to be discarded. It would have destroyed much of the renewed effort and enthusiasm engendered by the first Plan and would have appeared totally incompatible with earlier statements of support by the government for the five-year planning process(1); e.g.,

> "The federal government should negotiate with the research and granting Councils long term (five-year) funding arrangements. We are committed to the arm's length relationship between government and the Council and believe that independence and adequate response to clientele require longer range planning than is possible with fluctuating annual appropriations.
>
> ... we are committed to real (above inflation) increases in these appropriations."

The increments needed to restore the Council's funding base are identified by Table 43 and shown by Figure 38. They reflect the Council's 1984-85 request of $24.6 million rather than the $20 million increase that was eventually approved in late February 1985. Unfortunately, because of the one-shot nature of that February response, the increments identified by Table 43 will now show up as part of the second five-year commitment and will boost the accumulated requests over the next five years by a total of $210.1 million (current dollars). That represents 12.9% of the total new investment proposed by this document; a fact that is noted here and repeated later in Chapter 21 when the total investment challenge is presented.

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(1) Conservative Party policy as quoted in the "Canadian Association of University Teachers, Bulletin", August, 1984, Vol. 31(5): 7, 11

Table 43

Investment Increments Needed to Complete and Consolidate the First Five-Year Plan

(millions of dollars)

		Second Five-Year Plan					Total
a) Constant 1984-85 $	Base Year 1984-85	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90	
Total approved budget	311.6	287.1	280.8	280.5	280.5	280.5	
Budget requested to complete the first Five-Year Plan	316.2	316.2	316.2	316.2	316.2	316.2	
Funding increments required to complete and consolidate the first Five-Year Plan	N/A	29.1	35.4	35.7	35.7	35.7	171.6
b) Current dollars*							
Total approved budget	311.6	295.5	300.6	312.3	324.8	337.8	
Budget requested to complete the first Five-Year Plan	316.2	328.8	342.0	355.7	369.9	384.7	
Funding increments required to complete and consolidate the first Five-Year Plan	N/A	33.3	41.4	43.4	45.1	46.9	210.1

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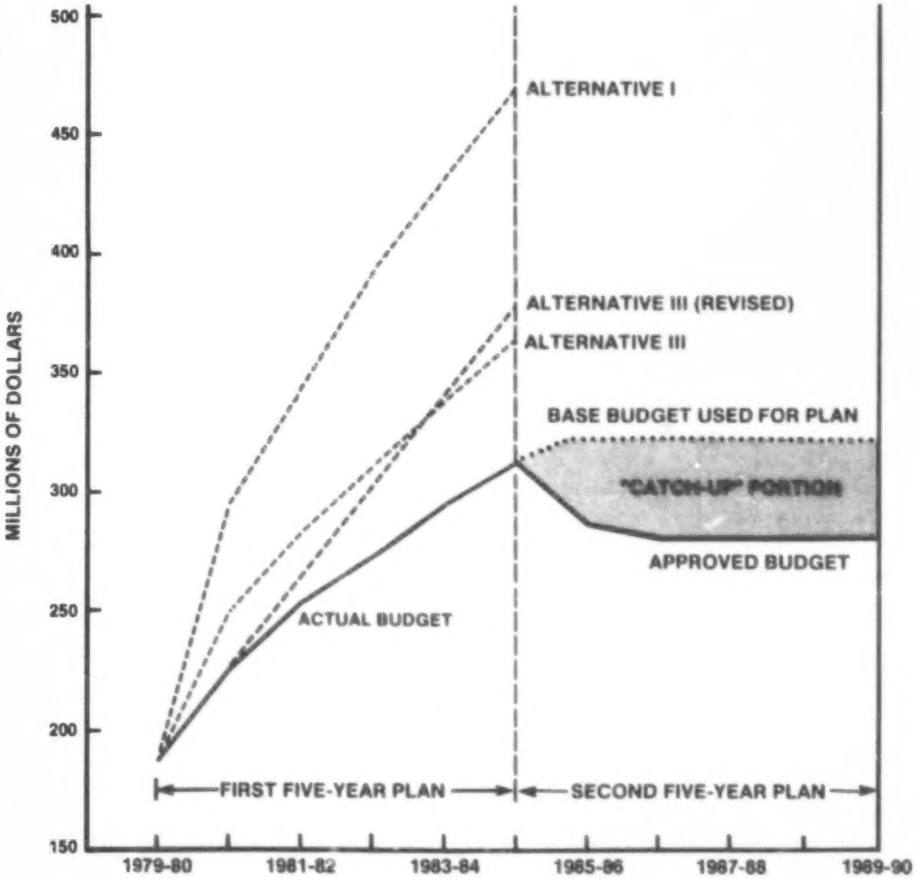
* Conversion from constant dollars to current dollars is based on an estimated inflation rate of 4% per year in all cases except for "Total approved budget" where Treasury Board has approved a 3% inflation allowance for 1985-86

Figure 38

The "Catch-Up" Element
(millions of constant 1984-85 dollars)



CHAPTER 15

DEVELOPING OUR INTELLECTUAL CAPITAL

As noted in previous chapters, NSERC's ability to ease the shortages of research talent over the next five years is limited by the number of students already in the undergraduate or graduate schools of Canada. However, the Council's programs themselves look **beyond** a five-year horizon as this is when the major impact of changes in the Council's research training programs will be felt most directly. For example, many of the undergraduates who will sample the challenge of research through NSERC's Undergraduate Student Research Awards program this year will emerge as highly trained PhDs in the early 1990s.(1) Similarly, the University Research Fellows appointed over the next five years will establish themselves as excellent replacements for the growing numbers of faculty retiring in the 1990s.

Two points must be kept in mind:

- NSERC's manpower-related initiatives will only achieve their targets if the totality of the Council's efforts succeed, i.e. there must be a healthy research environment to attract individuals to pursue a research-oriented career; and,

- the impact of NSERC's proposed actions over the next five years has already been incorporated into the researcher supply projections made in Chapter 12. The remaining shortages of talent over the next five years cannot be made up by NSERC's programs.

Existing Programs

Table 44 summarizes NSERC's proposal to expand **existing** programs so that they provide increased opportunities for research training. The following overall assumptions are incorporated into the projections:

- A further, but limited, increase in the number of **undergraduate** students in NSERC disciplines.

- Enrolments of Canadian and permanent resident students at the Masters degree level to increase by about 28% over the next five years. Comparable doctoral enrolments to reach a plateau in 1987-88, reflecting

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(1) A consultant's evaluation report of January, 1985 concluded that: "The study findings show that the USRA (Undergraduate Student Research Awards) program achieves its objectives to a very high degree" ... "In our opinion, there is no other program in Canada that operates on the same scale, serves the same clientele and offers the same benefits to its participants as the USRA program does". (Currie, Coopers & Lybrand, Management Consultants)

Table 44

Consolidation and Expansion of Existing Research Manpower Programs(1)

(Thousands of constant 1984-85 dollars)

Program Component:	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Undergraduate Student Research Awards	7 107 (2513)	9 000 (3000)	10 100 (3350)	11 100 (3700)	12 900 (4300)	14 700 (4900)
Postgraduate Scholarships	30 143 (2703)	31 950 (2940)	37 350 (3230)	39 750 (3400)	41 650 (3550)	43 350 (3670)
Postdoctoral Fellowships	3 554 (165)	4 600 (206)	5 100 (228)	5 500 (245)	5 800 (250)	5 800 (250)
University Research Fellowships	7 751 (279)	8 600 (296)	9 600 (327)	9 100 (352)	10 300 (373)	10 200 (385)
Industrial Research Fellowships	2 856 (175)	4 300 (223)	5 300 (264)	6 200 (293)	7 260 (349)	8 260 (391)
Totals - constant dollars	51,411 (5835)	58,450 (6665)	67,450 (7399)	71,650 (7990)	77,910 (8822)	82,310 (9596)
- current dollars	51,411	60,790	72,955	80,595	91,145	100,140

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(1) Numbers in brackets represent the projected number of awards held.

the fact that the large numbers of engineering students registered in doctoral programs in recent years will graduate at that time. An overall increase in postgraduate enrolment of about 25% is assumed over the next five years (See Figures 9 and 10, page 18).

With regard to the specific programs, the following comments can be made:

Undergraduate Student Research Awards: By 1990, it is proposed to have 4000 such awards tenable in the universities and 900 in industry. This mix could alter depending upon the interest of industry. In 1984-85, the final numbers were 2000 awards in the universities and 513 in industry.

Postgraduate Scholarships: Assuming that predicted increases in graduate school enrolments materialize, and that the same high standards of selection will be used, the Council projects that the following numbers of awards will be held in 1990: 3,300 regular Postgraduate Scholarships, 193 prestigious 1967 Science and Engineering Scholarships, 125 Industrial Postgraduate Scholarships and 52 special scholarships (e.g. Forestry and Science Librarianship). The comparable numbers in 1984-85 were 2,482, 141, 26 and 54 respectively.

Postdoctoral Fellowships: A modest growth from 165 awards in 1984-85 to 250 by 1990 is assumed based on PhD graduation trends and the maintenance of the current demanding selection criteria.

University Research Fellowships: Only 50 new awards per year have been assumed although recent experience would suggest a growth of about 20% in this number. The selection criteria are especially rigorous in this program and NSERC feels that the resulting level of excellence should be maintained. By 1990, about 385 fellows would be receiving various levels of NSERC salary support. The funding needed to maintain their research efforts is included in the projection for Operating Grants. (As an important footnote to this projection, in the 1985 fellowship competition, the universities nominated 199 young PhDs of which 57 were identified as being worthy of an award. Of those 57, 28 were currently in Canada, 20 in the United States, 8 in Europe and 1 in Australia. Over half, therefore, would be returning to Canada because of this program).

Industrial Research Fellowships: The number of new awards is expected to increase significantly; from 55 in 1984-85 to 125 in 1989-90. By 1990, about 391 individuals will be receiving support through this initiative.

New Initiatives

The proposed expansion of the existing initiatives is supply-limited for the next five years, but will still play a major role in efforts to produce Canada's future leaders of research and development. However, given the immediate challenge posed by the national R&D targets, further efforts are required to reinforce the existing research base. NSERC proposes three new programs, the first two aimed at increasing the numbers of new young researchers employed in jobs that make full use of their talents, and the last being a major effort to build and support research teams around highly respected research leaders. The following summarizes their objectives and projected investment requirements.

Visiting Postdoctoral Fellowships: The objective of this very modest program is to attract to Canada for a short period talented young foreign graduates at the PhD level.

The program is proposed for a number of reasons. In the first place, Canadian university research will derive an immediate benefit from the temporary presence of highly qualified researchers from other countries. Second, the links and personal relationships formed with foreign laboratories will improve our ability to tap into the new ideas and technologies originating in those countries. Furthermore, this program will enable Canada to compete more effectively with countries such as France, Germany and the U.S.A. that are already deriving benefits from similar programs of their own. Finally, such a program will enable Canada to attract top-rate young research talent from abroad for possible future employment, especially in those areas where urgently-needed Canadian research expertise is not yet adequate, but only if our immigration rules are eased.

If all of the above-noted reasons for this new program sound self-serving from a Canadian perspective, the simple reason is that they are. One could talk of the training benefits that will be realized by the Fellows themselves and ultimately by their home countries, some of which might be developing nations. However, if a postdoctoral fellowship program were not available in Canada, these same individuals would no doubt go to another country, thereby benefitting the R & D programs of that nation. It is in Canada's best interests to have access to this world pool of young researchers. They represent a valuable resource that is in increasingly short supply.

The proposed postdoctoral fellowship program should improve both the environment and pace of university-based research. It would complement to some extent a similar program that permits researchers to obtain experience in federal government laboratories. The number of new awards contemplated and the estimated costs are presented in Table 45. Each fellowship would be held for one year with a possible renewal for a second year. The awards could be targeted on disciplines and fields where particular needs exist. In the projections it is assumed that there will be 100 new awards each year and that all awards will be held for two years.

Postdoctoral Reorientation Fellowships: While the new program of Visiting Fellowships is designed to expand the pool of research talent in Canada, this proposal will improve the research productivity of existing graduates. Appendix 1 to this Plan summarizes a manpower supply-demand analysis for four general discipline areas within the natural sciences and engineering sector. It is evident that the projected shortages are more severe in some areas than in others. What is not so evident, but no less real, is that within each area, e.g. Agricultural and Biological Sciences, there may be critical shortages in some sub-disciplines but surpluses in others. The expansion of biotechnology-related research, for example, has resulted in a world-wide hunt for experienced researchers and a "sellers' market" for new PhDs who have specialized in that area. At the same time new graduates in some of the environmental or ecology fields will find the employment market flooded.

While a reorientation of researchers will not be readily possible in many cases, the Council believes that there are numerous instances where a one or two year period of up-dating or re-training could be the key to a more productive research career. Accordingly, this program of Reorientation Fellowships is being proposed. While the program will be open to any individual holding a PhD in the natural sciences and engineering, the principal target is the recent and unemployed or underemployed graduate. Council's normal criterion of quality will be exercised in the selection process and tenure of the fellowships will be restricted to Canadian universities unless no adequate training facilities exist in this country. Awards would be limited to training in fields identified by the Council on the basis of a current or projected shortage of research talent.

Table 45 includes the estimated expenditures associated with 50 new fellowships in 1985-86 and up to 100 new awards per year thereafter depending upon the backlog of qualified applicants. Each award would be for $23,300 (in 1984-85 dollars). A renewal for a second year would be possible and the investment projections assume that 50% of the award holders will pursue the renewal option.

Table 45

New Programs of Postdoctoral Fellowships
(thousands of constant 1984-85 dollars)

	Second Five-Year Plan				
	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
A. Visiting Fellowships					
- Number of awards	100	200	200	200	200
- Projected Budget	2,500	4,600	4,600	4,600	4,600
B. Reorientation Fellowships					
- Number of awards	50	125	150	150	150
- Projected Budget	1,200	2,900	3,500	3,500	3,500
C. Projected Total Expenditures:					
- constant dollars	3,700	7,500	8,100	8,100	8,100
- current dollars	3,850	8,110	9,110	9,475	9,855

NSERC Research Professorships: This proposed new program is considered vital to a significant improvement in the university research capacity and therefore to national aspirations for a greatly expanded R&D effort during the next five years.

Both the federal government and Canadian industry are increasingly expecting greater research contributions from our universities, recognizing that there are many new and rewarding research challenges that can be pursued best within the university environment. On the other hand, time available for university research in most cases is decreasing because of the pressures of undergraduate enrolments and teaching loads (Chapter 12). Furthermore, the critical mass or concentration of human and technical resources so essential in many of the new research fields is usually lacking.

NSERC saw these trends developing in 1979 and proposed a "Research Professorship" program for the first Five-Year Plan. Since funding levels for that plan were not sufficient to support launching of this major new undertaking, the proposal was put on hold and Council placed its emphasis instead on training the next generation of researchers.

During recent years, however, the Council has revived and elaborated on the proposal and has discussed it with the universities and with all provincial governments. As a result, the NSERC Research Professorship program, as presented in **Appendix I**, now carries a strong endorsement from across the country. It offers an effective and accepted method of quickly developing centres of research excellence around first-rate individuals. Given the right circumstances, the program should repatriate some of Canada's past exports of research leadership and it might also attract some of the world's top researchers to Canada. The program would be a central component of the Council's overall strategy during the next five years.

Recently, the Council has been able to launch a modest research professorship program called Industrial Research Chairs through cooperative NSERC-industry funding. This experience has demonstrated the strong industry support for such a program as well as the excellent calibre of the candidates available for such positions.

The projections for the new program are set out in Table 46. Although Council would be happier with higher growth for this important new initiative, our estimates are probably realistic in that they reflect both the supply of qualified candidates and the time and staff resources needed to conclude the lengthy, individual negotiations. If further growth proves possible, the high priority assigned to the program will ensure that Council would find added funds from other programs.

Table 46

Proposed Program of Research Professorships
(expenditures in thousands of dollars)

	Second Five-Year Plan				
	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Number of Professorships	22	44	66	88	110
Projected Expenditures:					
- constant 1984-85 dollars	8,800	14,100	19,400	24,700	30,000
- current dollars	9,150	15,250	21,820	28,895	36,500

Summary

Table 47 presents the total investment proposed for NSERC's expanded programs of research training and support of research positions. Notwithstanding this significant new investment, with expenditures growing by 134% in real terms over the five years, the total production of new research talent in the short term will barely keep pace with the expected attrition of the present research force. This unfortunate situation doesn't make the investment any less urgent, but it does point to a need to re-think our overall national effort in science education at all levels. It also emphasizes that we must equip the research talent we do have with state-of-the-art research equipment, and with research funding that will permit them to hire technical and professional assistants. We clearly must strive to do more with what we have.

At present, NSERC estimates that its programs provide either salary support or research support to some 17,000 individuals. Given the expansion reflected by Table 47, and the increased funding called for elsewhere, it is estimated that by 1990 a community approaching 30,000 would be benefitting from NSERC's endeavours and thereby contributing to the national R&D effort.

Table 47

Proposed Investment in Research Manpower Programs
(Thousands of constant 1984-85 dollars)

	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Consolidation and Expansion of Existing Programs	51 411	58 450	67 450	71 650	77 910	82 310
New Programs	-	12 500	21 600	27 500	32 800	38 100
Projected Expenditures:						
.constant dollars	51 411	70 950	89 050	99 150	110 710	120 410
.current dollars	51 411	73 790	96 315	111 530	129 515	146 495

CHAPTER 16

EQUIPMENT AND INFRASTRUCTURE

Given the targets for R&D over the next five years, and the shortages of skilled research talent identified in Chapter 12, it is pertinent to quote an observation made in NSERC's first Five-Year Plan:

> "...it is questionable whether Canada, having set such an ambitious target for its increase in R&D effort, can afford to ignore the less than optimal level of effectiveness and efficiency at which its small intellectual resource base is forced to operate as a result of inferior research tools".

If anything, that observation is even more pertinent today than it was in 1979. While significant improvements have been made in the state of research equipment over the past five years, the "catch-up" effort is not yet complete and the acquisition of new equipment is, of course, an ongoing and accelerating need. The new and exciting fields of research endeavour which all nations wish to embrace, require technologies and equipment that do not remain long at the cutting edge. For example, the **average** effective lifespan of equipment for the research facilities proposed by the Canadian Microelectronics Corporation is five years. By comparison, the average lifespan of university research equipment in 1980, as identified by NSERC's Task Force Study, was 12 years. Obviously, the equipment challenge as dictated by frontier research and the training of highly qualified manpower, is not going to disappear.

The above-noted quotation is even more applicable for another reason; the national R&D targets are even more ambitious now than was the case in 1979, and the shortage of skilled researchers all the more critical. Part of the solution to that shortfall is reflected in the attitude of "let's do more with the talent we already have". One of the supply-demand scenarios for research talent presented in Chapter 12 assumed just that. It was premised on an overall increase in effective investment by each researcher (at the Master's and PhD level) of 25%. Although shortages would still remain it produced a considerable reduction in the projected shortfall of researchers. Within that overall assumption of increased productivity was an assumed increased investment by each **university** researcher of 50%. That rate of potential increase reflected the fact that the output of the university research community is restrained by inadequate technical support staff that is only a fraction of that available in industrial and government laboratories. As a result, the graduate students, the research fellows and the professors themselves end up diluting their potential production by having to do without these essential peripheral services and, therefore, having to act as service technicians, etc. themselves.

An improved equipment and infrastructure situation within our universities is, therefore, an important element of the overall effort to meet our R&D objectives. Equipment funding, coupled with increased operating grants to fund more research technicians and professionals, will permit the existing research force to achieve a higher level of effectiveness and efficiency and it will ensure that the increasing numbers of graduate students are trained on the state-of-the-art equipment so essential to an increasing component of research activity.

Unfortunately, as documented in Chapters 3 and 13 of this report, the infrastructure so necessary for an effective research effort in our universities is deteriorating rather than improving. NSERC's efforts have filled some of the gaps produced by reduced university budgets, but a much more aggressive program is required by someone to stop this erosion, and turn the situation around so that we can truly get "more bang for the buck" from our current and future research leaders.

Council has identified and documented but one part, albeit a critical one, of the overall infrastructure dilemma (Chapter 13, pages 146 to 148) and has decided to take it into account in this Five-Year Plan. The magnitude of the challenge is such that the expansion of the Infrastructure Grants program constitutes a very significant portion of the request for increased funding; indeed it represents almost 20% of the total increased expenditure called for over the next five years. The Council also recognizes, however, that **part** of the need exists because of the withdrawal of university funding due to a significant erosion of provincial grants in relation to enrolment pressures. This leads one to ask why the federal government alone, through NSERC, should be responsible for correcting the erosion of research infrastructure, and for rebuilding infrastructure up to a more efficient level. NSERC can't answer that question; all it can do is identify the debilitating effect this situation is having on research and research training and quantify what is required to take appropriate corrective action. The required funding has been included in this Five-Year Plan but, as with the Research Professorship program (Chapter 15), has been separated out as being an initiative that would move NSERC into areas of support which, in the past, have been met in large part by the universities themselves.

The resolution of the full infrastructure dilemma will probably depend upon new federal-provincial agreements related to the support of postsecondary education and research. Such a resolution is urgently required, and, on the assumption that its programs may be chosen as a vehicle for corrective action, NSERC is developing an appropriate allocation and delivery mechanism.

Table 48 summarizes the equipment and infrastructure investments called for over the next five years. The major factors behind these projections are as follows:

- equipment grants themselves;
- industry-based manpower awards;
- Strategic Grants and University-Industry awards (which have self-contained equipment elements);
- Infrastructure Grants; and
- Research Professorships (which also reflect an initial equipment component).

The average rate of real growth in funding that results over the five year period for "The Recommended Plan of Action" is 23.6% per year.

Infrastructure Funding

The first Five-Year Plan envisaged a gradual increase of infrastructure support, to reach 12% of the net program budget by the end of the five years. The modest investment that actually took place fell far short of this level. Moreover, the definition of infrastructure was expanded somewhat to encompass the provision of research services which are not necessarily linked with a major piece of equipment.

Accordingly, the projections of Equipment and Infrastructure investment given in Table 48 reflect two items:

- an urgently required expansion of the existing program (10% real growth per year), and
- a positive response through NSERC to the incremental needs identified by the Task Force on Research Infrastructure. The $48 million (in constant 1984-85 dollars) requirement identified by that Task Force is introduced over a two-year period and is also expanded at 10% per year (real growth) to reflect the increasing research and research training initiatives proposed in this Plan. The reader is reminded that the Task Force only identified the incremental infrastructure services required to support **groups** of researchers. NSERC's ongoing program of infrastructure grants and the universities themselves will have to continue to provide the very significant existing levels of support and meet the expanding needs of individual researchers.

Table 48

Proposed Equipment and Infrastructure Investment
(thousands of constant 1984-85 dollars)

		Second Five-Year Plan				
	Base Year 1984-85	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Capital Equipment	20,321	37,380	43,070	47,980	53,620	59,560
Infrastructure:						
- Existing Program	12,728	14,000	15,400	16,940	18,635	20,500
- New Program	---	24,000	52,800	58,080	63,890	70,275
Total Investment:						
- constant dollars	33,049	75,380	111,270	123,000	136,145	150,335
- current dollars	33,049	78,395	120,350	138,360	159,270	182,905

CHAPTER 17

DISCIPLINE RESEARCH: THE HEART OF THE PROGRAM

The two previous chapters underlined the importance of properly equipping our university research laboratories with an increased supply of graduate students and faculty members, more state-of-the-art research equipment, and an improved infrastructure service. This, and subsequent chapters, now deal with what happens in those laboratories; the research and research training efforts themselves.

As explained in Chapters 4 and 13, NSERC Operating Grants are the sustaining force of university research; they provide the flexibility essential for pursuit of truly exciting research opportunities, and the continuity of effort needed for both research and research training. Approximately 60% of the average grant is used for salary support. It provides stipends for graduate students not on scholarships and pays the salary of laboratory assistants and research professionals. The existence of these stable teams of specialists enables research professors to undertake short-term research projects through the Strategic Grants program and through contracts awarded by industry and governments. Operating Grants are essential in their own right, but they are also the glue that holds everything else together.

Chapter 13 has outlined the circumstances that have led to greatly increased pressures on these grants, and to a real increase of only 9% in the average Individual Operating Grant over the past five years. The impossibility of pursuing costly modern research with an average grant that is worth 14% less in real terms than that of 1969-70 should be obvious to anyone. The first Five-Year Plan addressed the Operating Grants indirectly by providing support through equipment and human resources. Those efforts have to be continued, but, in addition, this second Five-Year Plan must address head-on the requirement for an adequate level of Operating Grants. The university research and research training effort cannot be sustained by an average Individual Operating Grant of only $21,857 per year.

This Plan approaches the Operating Grants program from two directions: first, the level of grant required by the established research force, and second, the needs of the young and highly competent new applicants who will provide the critical element of continuity through the 1990s.

Chapter 13 outlined how a good university researcher could very effectively use a research grant of $70,000 a year, an amount more than three times the current level. Obviously, that optimum level cannot be expected during this period of restraint. Equally clear, however, is the fact that significant real growth is absolutely essential if the university community is to increase its contribution to the overall R&D effort in a manner commensurate with growing expectations. Aside from the rapidly escalating costs of many research endeavours and the reduced level of university support, the training aspect itself is becoming very costly.

Figures 9 and 10 on page 18 project a continued expansion of graduate enrolment by Canadian and permanent resident students; an increase of 3,500 over the next five years. NSERC proposes to award only about 1,000 more scholarships, so there will be an additional 2,500 students seeking assistance through other scholarships and, in particular, through payments (stipends) from Operating Grants, the same grants that cannot now support the current level of graduate enrolment.

It is also critical that Operating Grants be increased to a level where they can provide reasonable stability to the research professionals that are hired on a "full time" basis and paid out of Operating Grants. These individuals, usually young PhD or Masters graduates, are the ones who give continuity to a research program. However, unlike their counterparts in government research labs, their existence in the universities is on a hand-to-mouth basis with no assurance of continuity.

For all the reasons mentioned above and in previous chapters, the Council is proposing a real growth of 10% a year for the budget that sustains the existing research force. Increases above that level will have to come through a combination of natural and forced attrition, the latter as a result of the Council's continuing emphasis on selectivity in the awarding of grants. These forces could produce an average grant in 1990 equal to about one half of that elusive $70,000 optimum grant, but the added funding will obviously not be disbursed in that manner. Operating Grants will be increased in a selective manner through peer review; in addition, some of the funding will be utilized to foster a concentration of resources in particular research areas. The Council will develop mechanisms to respond to the need for the development of a critical mass of research effort now so essential for a truly world-class effort in many expanding areas. This collectivity of effort will come about either at a single location or through a "networking" of the talent now existing at various centres across the nation.

Additional funding is also required to enable Council to adequately fund applicants requesting their first grant from NSERC; these researchers are essential to meet the manpower shortages expected during the next five years and into the 90s. There were 452 new applicants in 1984-85, down from 502 in 1983-84 and it is expected that this number will decline somewhat further, level off and then remain at about 400 new applicants per year during the planning period. Consequently, assuming continued pressure on university budgets, Council forecasts a constant level of 400 new applicants a year over the next five-year period. Furthermore, Council forecasts an average success rate of 75% in the competition with an average award growing in real terms by 10% a year over that of 1984-85. The end result of these projections is given in Table 49.

Table 49

First-Time Applicants - A Five-Year Projection

	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Number of New Applicants	452	400	400	400	400	400
Number of Awards	322	300	300	300	300	300
Average Starter Grant (constant 1984-85 dollars)	14 797	16 280	17 900	19 700	21 660	23 830
New Funds Required (First Year Grant only):						
.Thousands of constant 1984-1985 dollars	-	4 885	5 370	5 910	6 500	7 150
.Thousands of current dollars	-	5 080	5 810	6 645	7 600	8 695

Table 50 presents the investment trend produced by this proposed approach to established and new applicants. The table takes into account that in addition to new applicants, 50 new researchers each year will be winners of NSERC's University Research Fellowships and will be awarded Operating Grants at least equal to those of successful new applicants. The table also includes the salary stipends for E.W.R. Steacie Memorial Fellowships. These fellowships are NSERC's most prestigious awards. Presented to up to four exceptionally bright young professors each year, they pay the researcher's full salary for two years plus a significant Operating Grant supplement so that he or she can pursue research without a commitment to teaching and administrative duties. The projected budget for Discipline Research shows a real increase of 90% over the five-year period which represents 29% of the overall increment of funding called for by this Plan. In return, this investment will provide the stimulating research environment essential to the national effort.

Table 50

Proposed Investment in Discipline Research
(Thousands of constant 1984-85 dollars)

	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Operating Grants:						
.New Applicants	--	4 885	5 370	5 910	6 500	7 150
.Renewals of New Applicants	--	--	5 370	11 820	19 500	28 600
.New University Research Fellows	--	815	895	985	1 085	1 190
.Renewals of New URFs		--	895	1 970	3 250	4 765
.Established Researchers	142 383 (1)	156 620	172 285	189 510	208 460	229 310
(Average Grant per Established Researcher)(2)	(22.1)	(24.3)	(26.7)	(29.4)	(32.3)	(35.6)
Total Operating Grants	142 383	162 320	184 815	210 195	238 795	271 015
E.W.R. Steacie Fellowships	435	435	435	435	435	435
Total Investment:						
.constant dollars	142 818	162 755	185 250	210 630	239 230	271 450
.current dollars	142 818	169 265	200 365	236 930	279 865	330 260

---

(1) "Base Year" expenditures include new applicants and new University Research Fellows as part of the established research force but excludes $169,300 funding for Coop Grants

(2) "Established Researchers" includes all researchers holding Individual, Team, Project and University Research Fellow Operating Grants in 1984-85.

CHAPTER 18

THE TARGETED PROGRAMS: BRIDGING THE UNIVERSITY-INDUSTRY GAP

To say that Canada's economy is facing both new and growing problems in the 1980s is stating the obvious. Because many of the problems can only be resolved through the development and use of new technologies, it should be equally obvious that every effort must be made to effectively use the research and development expertise existing in this country. This requires an expansion of R&D activities and a greater interaction among the industrial, governmental and university sectors. Fortunately, all three sectors are recognizing this need and are taking action rather than lamenting the deficiencies.

However, in true Canadian fashion, we continue to exaggerate our deficiencies and downplay our accomplishments. The gap between the university and industrial research communities is not nearly as wide as some would present it, but there is still room for significantly increased interaction. As mentioned in Chapters 5 and 13, it is important to realize that many current activities are taking place **without** targets, **without** special programs and **without** special funding, simply because talented people sharing common fields of interest want the results of their labours to be effectively utilized. This healthy level of spontaneous activity and mutual respect is the base on which the more targeted programs of the Council are built.

By advocating an increased level of Operating Grants, NSERC hopes to expand the base of spontaneous university-industry interaction and to explore more effectively the frontiers of knowledge. At the same time, however, it wants to build on the successes of the targeted programs of Strategic Grants and University-Industry awards. These three programs cater to the whole gamut of research activity, ranging from that pursued solely for the sake of new knowledge to that which moves into the development and demonstration phase.

Council is convinced that NSERC's targeted programs are essential, given the urgent need to build stronger university-industry links. Accordingly, this second Five-Year Plan proposes significant growth in those activities, but a growth premised on realistic projections of interest and response rather than predetermined targets. Furthermore, the projections presented below are based on the continuing use of the peer review process; urgency must not be used as an excuse to support mediocrity.

Strategic Grants

As noted in Chapter 13, the greatest difficulty with this program is that participation by the university community has greatly exceeded expectations. Council is having more and more difficulty in responding to all of the proposals which warrant funding. Any repetition of the 26% funding rate of 1984 will discourage many of those who have devoted much time and effort to produce good relevant applications only to see them turned back due to lack of funds. In this regard, it is worth noting that within the Council's currently approved budget for 1985-86 ($295.5 million in current dollars), the funds available will only allow for an estimated funding rate of about 15% for new Strategic Grant applications. If this happens, the program will certainly fail; not through lack of research interest, but rather through lack of funding.

The funding projections of this second Five-Year Plan are given in Table 51 and are shown graphically in Figure 39. The major assumptions are the following:

- Interest in the currently identified strategic areas (see Appendix IV) will continue to grow. At one point, Council considered phasing down two of the original areas, Energy and Environmental Toxicology. However, recent cuts to R&D sponsored by federal government departments have impacted seriously on these two areas. As a result, university researchers who were receiving support through other federal programs may now turn to the Strategic Grants program. Accordingly, an early phase-out is not contemplated, as this would do great damage in areas which remain critically important to Canada and where graduate training is essential. For example, Canada is seriously short of good toxicologists.
- Two new areas of strategic importance will be added over the five-year period; one in 1986 and one in 1988. To select these new areas, Council will review the applications submitted to the "Open" category and identify those fields of research where the demand seems to warrant the creation of a new category of support.
- To be viable, the program's success rate should be in the range of 35% (in terms of funding requested). Over the past five years it has ranged between a high of 38% and a low of 25.5%. It is proposed to target for a funding rate of 31% in 1985-86 and increase that by 1% each year. These are maximum targets; the actual funding rates may be less, depending upon the quality of the applications in any one year.

The end result of these assumptions is a real growth of 15% per year over the next five years, resulting in a doubling of the 1984-85 budget by 1989-90.

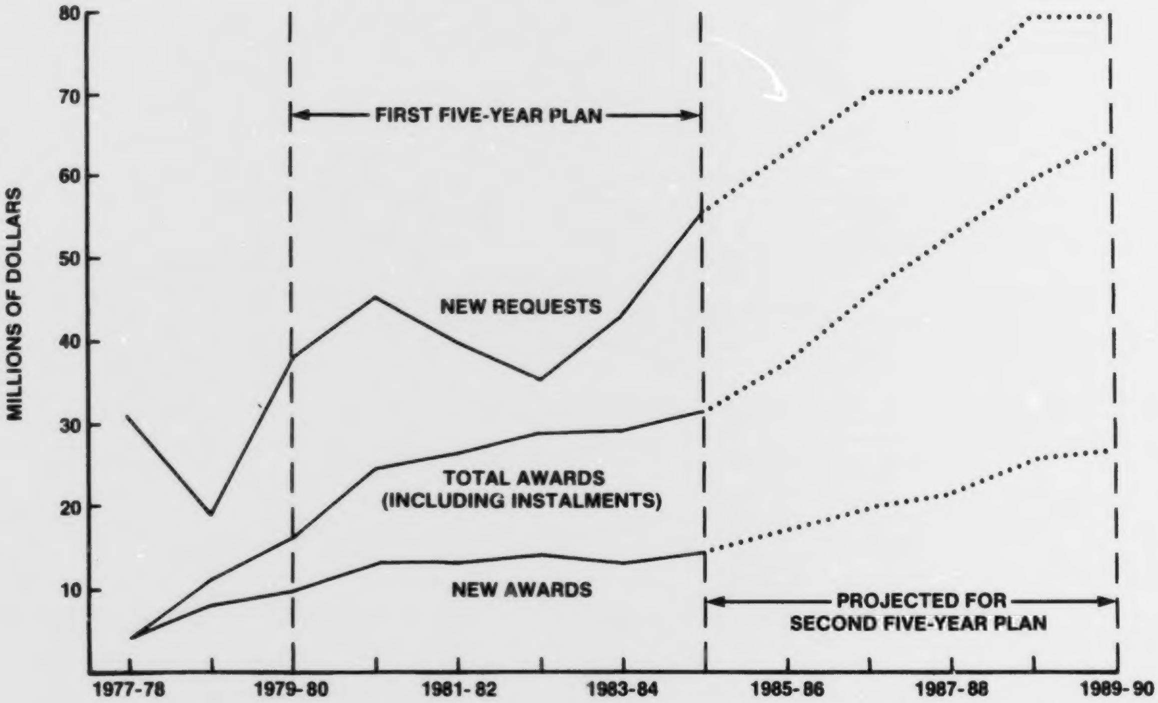
Table 51

Projected Investment in Strategic Research Grants
(thousands of constant 1984-85 dollars)

		Second Five-Year Plan				
	Base Year 1984-85	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
New Requests	56,496	63,700	71,600	71,600	79,500	79,500
Funding Rate (%)	25.5%	31%	32%	33%	34%	35%
Projected Budgets:						
- New Awards	14,431	19,700	22,900	23,600	27,000	27,800
- Installments	17,823	20,200	25,000	30,900	33,600	36,800
Totals:						
- constant dollars	32,254	39,900	47,900	54,500	60,600	64,600
- current dollars	32,254	41,495	51,810	61,305	70,895	78,595

Figure 39

Strategic Grants - Funds Requested and Awarded
(thousands of constant 1984-85 dollars)



University-Industry Initiatives

It is of course dangerous to make five-year projections on the basis of one year's experience. However, interest in Council's new University-Industry program shows no sign of let-up. The announcement of the program in January, 1984 gave rise to a surge of applications, which was followed by a slowing of demand. Since the fall of 1984, however, there has been a steady increase in the number of applications, many of them involving very substantial sums of money. There is every indication that this trend will continue as industry comes to see the value of closer ties to the university research community.

At the same time, however, the Council recognizes that there are limits to both the rapidity and the degree to which these two communities can and should be brought together through such special programs. Attitudes in many cases are slow to change on both sides; other programs of support exist, albeit with different mechanisms; and there is a limit to the percentage of university-based research that **should** be influenced by today's perceived notions of long-term industrial needs. In fact, it would be very wrong to see the university laboratories and researchers as simply an adjunct or alternative to industrial laboratories. We must protect and nourish free and fundamental research at the universities as it is a unique and essential component of the overall national R&D effort; it is thanks to this research that innovative work with industry can prosper at all. Thus, while there exists a great potential for more effective interaction, there are also real limitations. Keeping this in mind, and using the best available indicators of interest and quality of applicants, Council produced the projections given in Table 52. Obviously, the allocation of funds among the various activities is approximate. Council is confident, however, that the totals shown can be effectively used to invest in excellent joint research and development efforts.

At the same time, the Council endorses a growing consensus in the community that government support of joint efforts be subjected to a rigorous peer review process. University-industry cooperation has suddenly become quite fashionable; all too often such activities become driven by spending targets rather than by the quality of the proposed work. Such a trend would not only be wasteful of scarce resources, it would also divert interest away from the Council's programs that have more demanding quality control mechanisms. The mutual respect so essential for an effective interface could ultimately be lost.

Table 52

Projected Investment for University-Industry Cooperative Activities
(thousands of constant 1984-85 dollars)

Type of Activity	Base Year 1984-85 Expend.	Base Year 1984-85 Allocation	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
R & D Projects	7355	7,900	8,700	9,600	10,500	11,600	12,700
Shared Equipment	1064	1,000	1,500	2,000	2,000	2,000	2,000
Research Chairs	416	1,500	4,700	5,800	6,900	7,900	9,000
Affiliations	--	200	200	200	200	200	200
Workshops	65	100	100	100	100	100	100
Visiting Fellowships	128	200	225	250	275	300	325
Totals:							
- constant dollars	9,028	10,900	15,425	17,950	19,975	22,100	24,325
- current dollars	9,028	10,900	16,040	19,415	22,470	25,855	29,595

Canadian Microelectronics Corporation

As explained in Chapter 5, NSERC played a major role in the development of this unique cooperative effort aimed at increasing research and research training in the area of very large scale integrated circuits. As NSERC is currently the only source of funds for the Corporation , the second Five-Year Plan must reflect the budget needed to maintain current program activities. Table 53 presents the best estimates possible at this time and shows the increases proposed over currently approved budgets.

Table 53

Investment in the Canadian Microelectronics Corporation
(Phase I, National Microelectronics Facility)
(thousands of constant 1984-85 dollars)

	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Budget	5,100	2,550	1,900	2,000	---	---
Budget Increments	--	--	--	--	3,000	3,000
Totals:						
- constant dollars	5,100	2,550	1,900	2,000	3,000	3,000
- current dollars	5,100	2,650	2,055	2,250	3,510	3,650

As noted by Table 53, the funding proposed is only for the first phase of the "National Microelectronics Facility"; the VLSI design network. Phase II, which has been presented to the Council, calls for a five-year expenditure of $150 million (in constant 1984-85 dollars) for two world-class research centres in the areas of process technology, new materials and devices, etc. This proposal carries broad industry and university support and is seen as a key element in maintaining a viable Canadian microelectronics industry. Council has endorsed the proposal; it is not part of this Plan simply because NSERC is of the view that the government should consider its merits as part of an overall discussion of the industry and its needs, not as part of NSERC's ongoing programs.

Summary

Table 54 presents the total investment proposed for the targeted programs of the Council.

Table 54

Proposed Investment in Targeted Grants
(thousands of constant 1984-85 dollars)

Activity	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Strategic Grants	32,254	39,900	47,900	54,500	60,600	64,600
University-Industry Cooperative Activities	9,028	15,425	17,950	19,975	22,100	24,325
National Microelectronics Facility (Part I)	5,100	2,550	1,900	2,000	3,000	3,000
Totals:						
- constant dollars	46,382	57,875	67,750	76,475	85,700	91,925
- current dollars	46,382	60,190	73,280	86,025	100,260	111,840

CHAPTER 19

THE FLEXIBILITY COMPONENT

Supporting the major thrusts identified by the four previous chapters is a grouping of smaller, but very important programs that permit fine-tuning of the total program package. They carry an importance that goes well beyond their budgets, which in many cases is quite modest. As described in Chapters 7 and 8, these programs range from mechanisms to replace such things as used X-ray tubes, all the way to the support of Canadian participation in a space experiment. They provide additional assurance that Canada has a nation-wide competence in broad fields of research and development. The required budget levels in some instances can be predetermined to a considerable extent; at the other extreme, however, the programs exist **because** of the impossibility of forecasting adequately either the timing or the cost of unique research opportunities. As a result, the investment projections can only be approximations at best.

Projections of required investment for each of these initiatives will be presented, but before doing so the interrelationships of all NSERC programs should be established. This is done in a conceptual way by Figure 40 which breaks all initiatives into three approximate categories:

- **"Bootstrap" Programs:** To develop research competence in areas where there are identified problems in terms of the overall level of activity or lack of success through the usual peer review competitions.

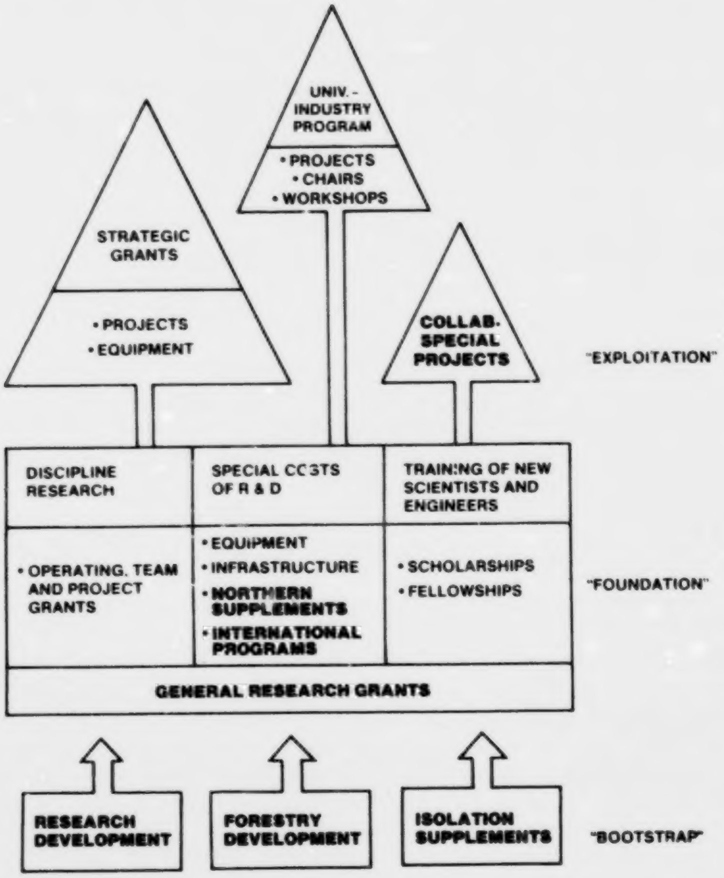
- **"Foundation" Programs:** These consist mainly of the three major programs already dealt with, and supported by a program of General Research Grants to University Presidents.

- **"Exploitation" Programs:** Activities that move the research effort closer to the user community or exploit particularly strong Canadian research capabilities in unique or special projects.

Within this general framework, the programs presented in bold face in Figure 40 are dealt with by this chapter.

Figure 40

Conceptual Model of NSERC's Programs


UNIV. - INDUSTRY PROGRAM
• PROJECTS
• CHAIRS
• WORKSHOPS
STRATEGIC GRANTS
• PROJECTS
• EQUIPMENT
COLLAB. SPECIAL PROJECTS
"EXPLOITATION"
DISCIPLINE RESEARCH
SPECIAL COSTS OF R & D
TRAINING OF NEW SCIENTISTS AND ENGINEERS
• OPERATING, TEAM AND PROJECT GRANTS
• EQUIPMENT
• INFRASTRUCTURE
• NORTHERN SUPPLEMENTS
• INTERNATIONAL PROGRAMS
• SCHOLARSHIPS
• FELLOWSHIPS
"FOUNDATION"
GENERAL RESEARCH GRANTS
RESEARCH DEVELOPMENT
FORESTRY DEVELOPMENT
ISOLATION SUPPLEMENTS
"BOOTSTRAP"

General Research Grants

This program of special grants to university presidents is very much a fine-tuning exercise. Its objectives are described in Chapter 8 (pages 99 and 100). The program is a vital part of NSERC's overall activities as it provides, in an effective manner, the type of financial support that could not be provided as efficiently from a centralized office in Ottawa.

Accordingly, the Council is proposing that the program continue at a level of funding which represents approximately 5.8% of the previous year's funding in the Operating, Strategic (excluding equipment), Infrastructure (excluding the proposed program expansion) and Research Development Grants programs. The growth in those various grant programs therefore forms the basis of the projection given in Table 55.

Table 55

Projected Investment for General Research Grants
(thousands of constant 1984-85 dollars)

	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Totals:						
- constant dollars	9,487	10,800*	12,525	14,360	16,300	18,420
- current dollars	9,487	11,230	13,550	16,150	19,070	22,410

---

* Includes $9,486,950 paid in 1984-85

Research Development Grants

The current state of flux of this program was explained in Chapter 7. The Council is convinced that special assistance to small and francophone universities is necessary because of the unique challenges they face in developing and sustaining research excellence. At the same time, there is a sense of dissatisfaction with the overall success of some of the past and current initiatives and a feeling that new approaches may be required. It was for this reason that a very detailed review of past accomplishments was initiated. The conclusions and recommendations of that study are not yet available and thus cannot be incorporated into this Five-Year Plan.

As an interim step, the projection of funding given in Table 56 reflects a real growth of 10% each year during the five-year period. However, recent allocations have not been fully used because of a lack of worthy project grant proposals; therefore, Table 56 compares the actual **expenditures** and the budget **allocations** in 1984-85 to the interim budget increases. The resulting real increase over the five-year period is 152% over the 1984-85 expenditures.

Table 56

Tentative Projection of Investment in the Research Development Program
(thousands of constant 1984-85 dollars)

	Base Year 1984-85		Second Five-Year Plan				
	Expenditures	Allocation	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Totals:							
- constant dollars	2,082	3,262	3,590	3,950	4,340	4,775	5,255
- current dollars	2,082	3,262	3,735	4,270	4,880	5,585	6,390

It is quite probable that a revitalized and redirected program of support for Canada's francophone universities will give greater importance to efforts that will expand the pool of new francophone research talent. Like so many of NSERC's programs, it would be responsive in nature, so the funding levels required would eventually be determined by the level and quality of applications. A "quota system" administered without regard to quality is not being contemplated; it is contrary to NSERC's philosophy and the long-term health of the francophone research community. However, given the recent initiatives of the Quebec Government(1) and the potential for reinforcing and building on those actions, it is highly probable that expenditures exceeding those presented by Table 56 will be warranted. If that situation develops, the added funds would be found from within the totality of the budget of this Five-Year Plan.

Also within the context of a revitalized program, the current initiative to expand eligibility to the Research Development program to six small anglophone universities located west of the Province of Quebec should go a significant way towards addressing the problems and improving the research capability of those institutions. It is also possible that other small anglophone universities will be admitted to this special program over the next few years. As mentioned in Chapter 7, all of these universities are being asked to submit developmental plans to NSERC, as our experience demonstrates that one achieves the greatest degree of success in those cases where the players are willing to focus their efforts. Although a difficult task, NSERC is convinced that the positive effects of this procedure will reach well beyond the Research Development program itself.

Forestry Development Program

This is a program that presents problems with regard to budget projections. While the special "postdoctoral assistantships" in forestry have proven quite effective, it is still too early to judge the success of the newer forestry developments grants. Final reports on some of the initial grants will be received during 1985 and recent visits to the universities have produced mixed reactions. However, this program must be made to work either in its current form or through other mechanisms that extend directly rather than indirectly to faculty outside of the forestry schools themselves. Building on the successes of existing initiatives, an effective forestry development program is envisaged for the next five years. The investment projections given in Table 57 reflect a real growth of 5% a year. If the results of ongoing efforts warrant, further increments might be found through a very modest redistribution of the overall Council budget.

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(1) Programme d'actions structurantes pour le soutien d'équipes de recherche liées au virage technologique.

Table 57

Projected Investment in the Forestry Development Program(1)
(thousands of constant 1984-85 dollars)

	Base Year 1984-85		Second Five-Year Plan				
	Expenditures	Allocation	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Totals:							
- constant dollars	557	1,111	1,160	1,225	1,290	1,350	1,420
- current dollars	557	1,111	1,210	1,325	1,450	1,580	1,730

---

(1) Includes forestry development grants and forestry postdoctoral assistanships.

Isolation and Northern Supplements

Requests for Northern Supplements are evaluated by both the regular peer review committees and by a group of experts on the logistics of northern research. Isolation Supplements are awarded by a formula based on the number of Operating Grants received through the peer review process. The projections for the Five-Year Plan assume that researchers at small, isolated universities will continue to experience modest but real success in the Council's competitions, and that the challenges of the north will always attract some of Canada's best research talent. Accordingly, real growth of 10% per year over the 1984-85 expenditures has been projected for the next five years for each program.

Table 58

Projected Investment in Isolation and Northern Supplements
(thousands of constant 1984-85 dollars)

		Second Five-Year Plan				
	Base Year 1984-85	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Isolation Supplements	182	200	220	240	265	295
Northern Supplements	302	330	365	400	440	485
Totals:						
- constant dollars	484	530	585	640	705	780
- current dollars	484	550	630	720	825	950

International Programs

This package of special programs is explained in Chapter 8, (pages 102 and 103). Given the relatively modest scale of the budget and the flexibility Council has to make changes in funding allocations, as required, no effort has been made to estimate a possible expansion of the formal "bilateral exchanges". The cost of such an expansion would depend upon the country or countries concerned. Table 59 does, however, assume modest increases in the two other international programs.

Table 59

Projected Investment in NSERC International Programs (1)
(thousands of constant 1984-85 dollars)

Program	Base Year 1984-85		Second Five-Year Plan				
	Expenditures	Allocation	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Bilateral Exchanges	317 (90)	425 (75)	425 (75)	425 (75)	425 (75)	425 (75)	425 (75)
International Collaborative Research	164 (45)	150 (60)	200 (80)	200 (80)	200 (80)	200 (80)	200 (80)
International Scientific Exchanges	373 (69)	375 (70)	500 (90)	500 (90)	500 (90)	500 (90)	500 (90)
Totals:							
- constant dollars	854	950	1,125	1,125	1,125	1,125	1,125
- current dollars	854	950	1,170	1,215	1,265	1,315	1,370
- number of awards	(204)	(205)	(245)	(245)	(245)	(245)	(245)

---

(1) Number of awards given in brackets

Collaborative Special Projects

The fact that this program is last in this presentation is in no way a reflection of its relative importance. On the contrary, there is a rapidly growing need for the Council to have a **major** program with enough flexibility to be able to respond to important proposals that do not fit into the categories and rigid timetables of the Operating and Strategic Grants programs. The Council's regular budget is heavily committed to these latter programs and it should not be necessary to make a submission to Cabinet for special funding each time a unique, urgent and exciting research opportunity arises; in any event, Ministers would not accept such a procedure.

Accordingly, given the growing interest in collaborative endeavours, both nationally and internationally, Council must maintain an adequate reserve of funds to exploit exciting opportunities; the existing allocation of $2 million can no longer cope with the growing demand. For example, NSERC's share of the ongoing membership fee in the international Deep Ocean Drilling Program is $500,000 and the funding of university experiments in that program will probably push the annual cost beyond $1 million. Phase II of the widely-heralded Lithoprobe program advocated by the earth science community entails an annual cost of $6 million (of which one-half is sought from NSERC). As a final example, consider the preparation of the university-based experiments that would be associated with proposed Canadian participation in the "Space Station" program.

Obviously, Council needs a program enabling it to support at least some of these unpredictable but important proposals; many of these will permit us to concentrate resources and reach the critical mass that is so essential in R&D. The Collaborative Special Projects program is the proper vehicle to cope with this need, and a small budget increase will not be adequate. Accordingly, Table 60 is divided in two parts: a 5% real growth per year to maintain support to the more modest applications, and a significant expansion of funding that will provide Council with a reserve equal to about 2% of its total program budget to respond to major exciting opportunities.

Table 60

Projected Investment in Collaborative Special Projects
(thousands of constant 1984-85 dollars)

	Base Year 1984-85		Second Five-Year Plan				
	Expenditures	Allocation	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Existing Program	1,056	1,986	2,085	2,190	2,300	2,415	2,535
Expansion	--	--	7,955	9,650	10,830	12,155	13,475
Totals:							
- constant dollars	1,056	1,986	10,040	11,840	13,130	14,570	16,010
- current dollars	1,056	1,986	10,440	12,810	14,770	17,045	19,480

Summary

It would be a grave error to dismiss the activities discussed in this Chapter as peripheral and unimportant. They are very important; if they did not exist and were not functioning well, Council's major programs would have to be restructured (and in many ways diluted in impact) to serve the same purposes. For this reason, the total investment projections presented in Table 61 are a vital component of this Plan.

Table 61

Investment Projections for Development and General Programs

(thousands of constant 1984-85 dollars)

Program	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
General Research	9,487	10,800	12,525	14,360	16,300	18,420
Research Development	3,262	3,590	3,950	4,340	4,775	5,255
Forestry Development	1,111	1,160	1,225	1,290	1,350	1,420
Isolation and Northern Supplements	484	530	585	640	705	780
International	950	1,125	1,125	1,125	1,125	1,125
Collaborative Special Projects	1,986	10,040	11,840	13,130	14,570	16,010
Other (1)	2,886	3,175	3,490	3,840	4,225	4,650
Totals:						
- constant dollars	20,166	30,420	34,740	38,725	43,050	47,660
- current dollars	20,166	31,635	37,575	43,560	50,360	57,985

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(1) Includes Scientific Publication, Conference, Workshop and Seminar, Travel, New Research Idea, Miscellaneous and Coop Grants.

CHAPTER 20

THE DELIVERY SYSTEM

Approval of the second Five-Year Plan would continue the transition towards a more proactive style of program management which began with the first Five-Year Plan. As noted in Chapter 9, the pursuit of programs involving target areas, detailed three-party negotiations, and greater selectivity, have moved NSERC in that direction.

The degree of staff involvement will become even greater during the next five years. Consider the following examples:

- expansion of both the University and Industry Research Fellowships programs will involve more than 750 Fellows by 1989-90, each file requiring careful individual attention, not only during the selection process, but also during tenure of the award;

- introduction of the prestigious program of Research Professorships, each of the forecast 110 appointments requiring careful negotiations with the host university, ongoing review mechanisms and complex administrative procedures;

- a continued push to greater selectivity in the awarding of research grants, necessitating further interaction with the peer committees, and mechanisms to cope with the enquiries and appeals of an increasing population of unsuccessful applicants;

- a move to establish a greater concentration of research or the development of a critical mass in particular fields, requiring a very considerable amount of committee and staff work;

- continuation of the expansion of the Infrastructure and Major Installation programs, with each major application requiring extensive review, discussion and follow up;

- expansion of the Strategic Grants program and the University-Industry program which, by their very nature, demand intensive staff involvement; and,

- increased communications with the client community, with federal and provincial government agencies and with research organizations in other countries, which will become increasingly important and time-consuming as NSERC's programs become a major element of the overall national R & D effort.

These are just examples; what should be abundantly clear is that past experience is no longer a valid guide for projections of personnel and administrative needs. The 2% overhead of 1979 is a thing of the past and the Council is currently stretched to the limit to hold the overhead to a very modest 3% of total budget. It is only through the tremendous dedication of the staff itself and of the 500 or so volunteer members of the Council's committees that this level has been maintained; even so, the quality of service and degree of control is less than adequate in some instances.

As the overall level of funding, the mix of programs, and the choice of delivery mechanisms will have a major bearing on the percentage of overhead that will be required, the future requirements are extremely difficult to forecast. However, if the Recommended Plan for the next five-years is adopted and funded, it is NSERC's view at this time that it can probably continue to operate at about the 3% overhead level; in other words, economies of scale in some of the programs will help offset the far more labour-intensive operation in others. The overall administrative effort, however, would continue to be very lean and subject to breakdown due to increased demands on it by either the client community or by the ever expanding auditing and monitoring requirements of the central agencies of government. If such breakdown were to occur, then NSERC would have to request staffing levels exceeding those projected herein. The added financial costs would be met by a transfer of funds from the program budget of the Council.

The projections shown in Table 62 are premised on the mix of programs, delivery mechanisms and funding requirements outlined in the Recommended Plan. If this mix were altered in any way, e.g. by adoption of a detailed peer review mechanism in the expanded Infrastructure program rather than "formula" financing, or by assigning greater priority to NSERC's targeted and negotiated programs, then these projections would no longer be valid; they would have to be adjusted upwards to reflect the greater degree of involvement by the Council and its staff in program management. Equally important is the assumption that Council's efforts will continue to carry the strong support of the research community, demonstrated by the willingness of hundreds of researchers to devote weeks of intensive voluntary effort to maintain the quality of the peer review system.

Table 62

Administrative Resource Needs
(thousands of constant 1984-85 dollars)

		Second Five-Year Plan				
	Base Year 1984-85	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Operating Expenditures	9,308*	12,290	15,095	16,945	19,015	21,085
% of Total Budget	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Person-Years	138	165**	200	225	250	275

---

* Excluding transfer of $1.7 million from the Grants budget to the Administration budget for the acquisition of a computer facility. Including this one-time transfer, administration costs amounted to 3.5% of the total budget in 1984-85.

** 148 Person-Years now approved.

Figure 41 shows the growth in the Council's budget (expressed in constant dollars) and in the authorized person-year complement over the 1979-80 base. The more proactive management approach adopted by Council is reflected in the faster rate of growth in the number of person-years required to manage and administer its awards programs. This is also reflected in Figures 42 and 43, which show the change in the number of dollars administered per employee as well as the change in the administration cost per dollar awarded over the last five years. As mentioned earlier, it is expected that these volume and overhead cost indicators will remain at their current levels during the next five years.

Figure 41

Index of Total NSERC Budgets and Authorized Person-Years
(1979-80 = 100)

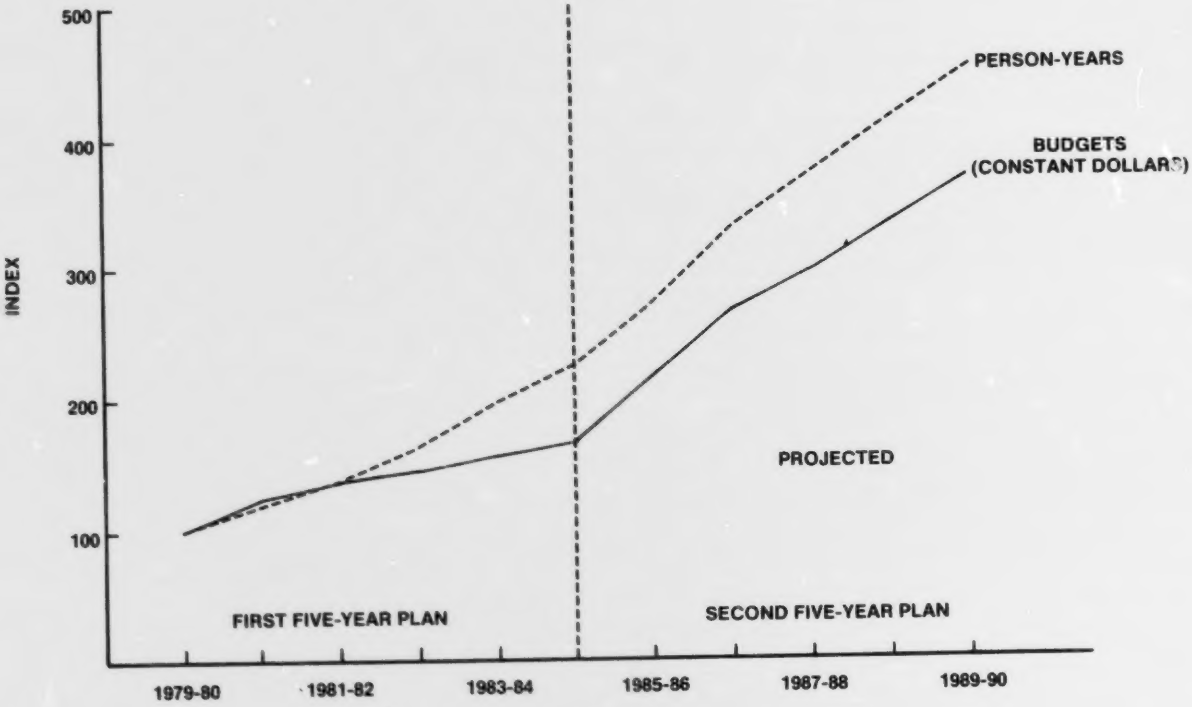


Figure 42

NSERC Program Funds Administered per Person-Year
(constant 1984-85 dollars)

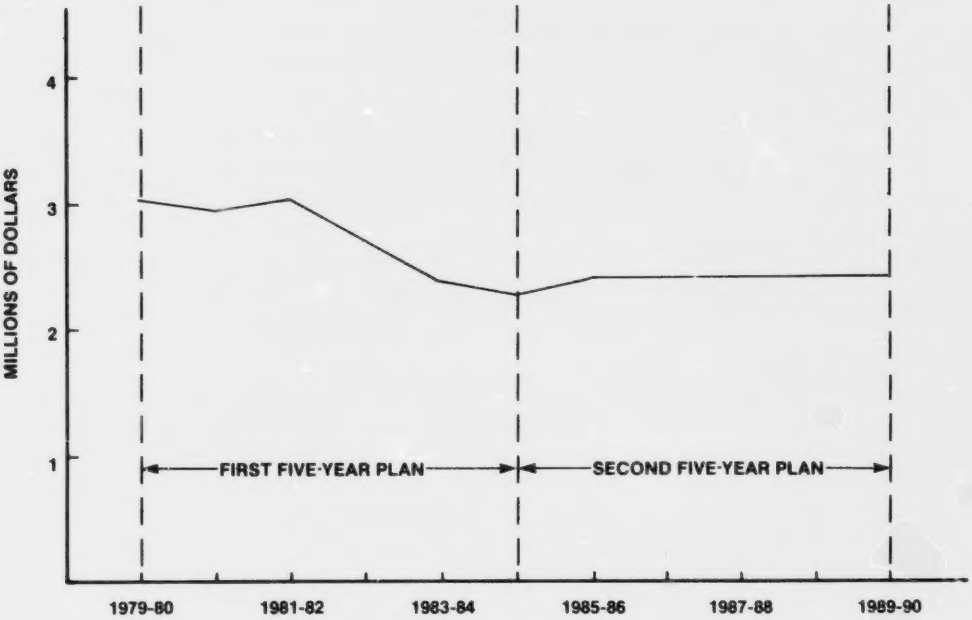
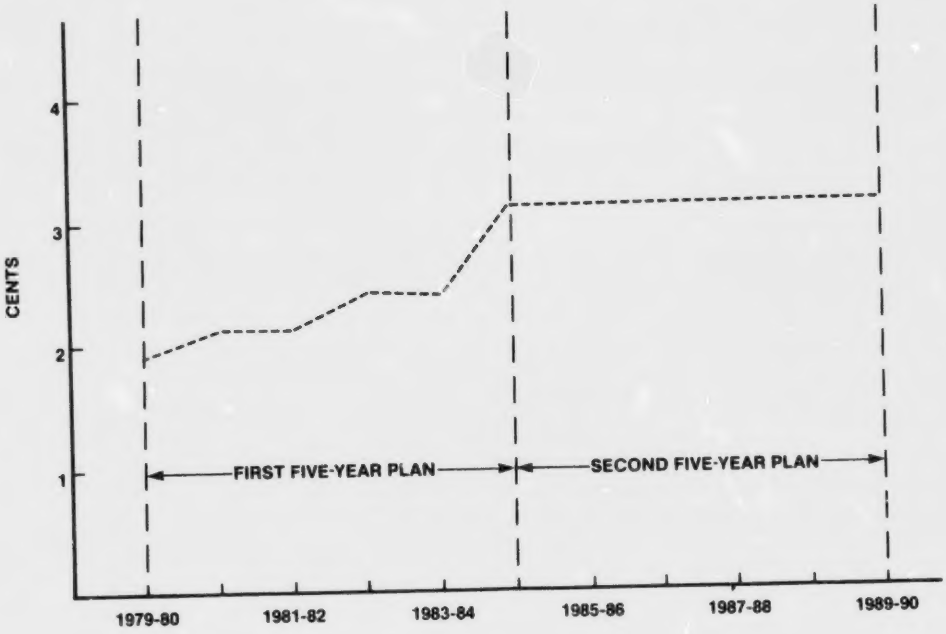


Figure 43

NSERC Administration Costs per Dollar Granted
(constant 1984-85 dollars)



CHAPTER 21

THE TOTAL INVESTMENT

Before assessing the overall investment needs, it is worth repeating a few of the overriding considerations.

- The recommended total investment is in no way a predetermined target; rather it is the summation of the needs of carefully assessed individual components.

- Those components are very interdependent; therefore the mix of the various initiatives is as important as the total investment.

- The manpower training initiatives are supply-limited; NSERC would be calling for an even greater effort if there were more students available in its disciplines. Accordingly, the Plan must reflect both the need for a larger research population and more effective use of the talent now available to us.

- NSERC's first Five-Year Plan did not receive either the amounts or the continuity of funding it called for. As a result, a significant fraction of the proposed investment is required just to stabilize the funding increments achieved by the first Plan, thereby establishing a firm starting point for the next five years.

- The actions proposed are not, by themselves, the total answer to Canada's R&D requirements. However, they represent an essential prerequisite for the overall effort; they provide the base of talent and knowledge upon which everything else eventually depends.

With these thoughts in mind, all of the projections of the preceding chapters are now brought together to form what henceforth will be called the **Recommended Plan of Action,** NSERC's second Five-Year Plan.

The Recommended Plan of Action

The investment needs of each of the carefully developed components is presented in Table 63; this is NSERC's Recommended Plan of Action for the next five years; it is that essential "bridge to the '90s". The rate of growth in all components is substantial and the overall budget of NSERC would rise by 126% in real terms by the end of the decade. The largest single component of growth reflects the urgent need for increased "infrastructure" for the research and research training effort. "Infrastructure" in this case represents both the acquisition of equipment and the ancillary services so essential for an effective research program. Most of that growth (67%) would be directed to this service component, and reflects NSERC's proposal to carry a larger share of what is an essential, but eroding part of the total research effort.

Table 63

The Recommended Plan of Action
(millions of constant 1984-85 dollars)

Activity	Base Year 1984-85	Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1939-90
Research Manpower	51.4	71.0	89.1	99.2	110.7	120.4
Research Infrastructure	33.1	75.4	111.3	123.0	136.1	150.3
Discipline Research	142.8*	162.8	185.2	210.6	239.2	271.5
Targeted Research	46.4	57.9	67.8	76.5	85.7	91.9
Development and General Programs	26.9	30.4	34.7	38.7	43.1	47.7
Total Program Investment	300.6	397.5	488.1	548.0	614.8	681.8
Administration (P-Y)	11.0 (138)	12.3 (165)	15.1 (200)	16.9 (225)	19.0 (250)	21.1 (275)
Total Investment:						
- constant dollars	311.6	409.8	503.2	564.9	633.8	702.9
- current dollars	311.6	426.2	544.3	635.4	741.5	855.2

---

* Final expenditures totalling $169,300 under the phased-out Coop Grants program are included in "General Programs" in 1984-85.

The increments shown in Table 63, however, reflect more than the needs of this second Five-Year Plan. The Plan was developed early in 1985, at a time when Council was still striving to complete its first Plan through a funding increase for 1984-85 and a consolidation of its budget at a "base" level of $316.2 million (constant 1984-85 dollars). As events transpired, however, a welcomed $20 million increase brought the 1984-85 funding to only $311.6 million; furthermore, the $20 million was available for just one year. As a result, the Council lost that $20 million plus other short-term funds as of 1 April 1985.

Thus, because one cannot complete a bridge on a foundation that is crumbling, the call for increased investment has to meet two challenges:

- first, bring the ongoing base up to $316.2 million (in constant 1984-85 dollars) to firm up the foundation and provide continuity of funding for the activities launched within the first Plan; and

- second, provide for the growth called for by this second Five-Year Plan.

Figure 44 and Table 64 present a breakdown of the total projected investment in constant 1984-85 dollars, while Figure 45 and Table 65 provide the same data in current dollars. Table 66 breaks the budget requirements down in terms of the two above-noted challenges.

Figure 44

Required Investment for the Recommended Plan of Action
(millions of constant 1984-85 dollars)

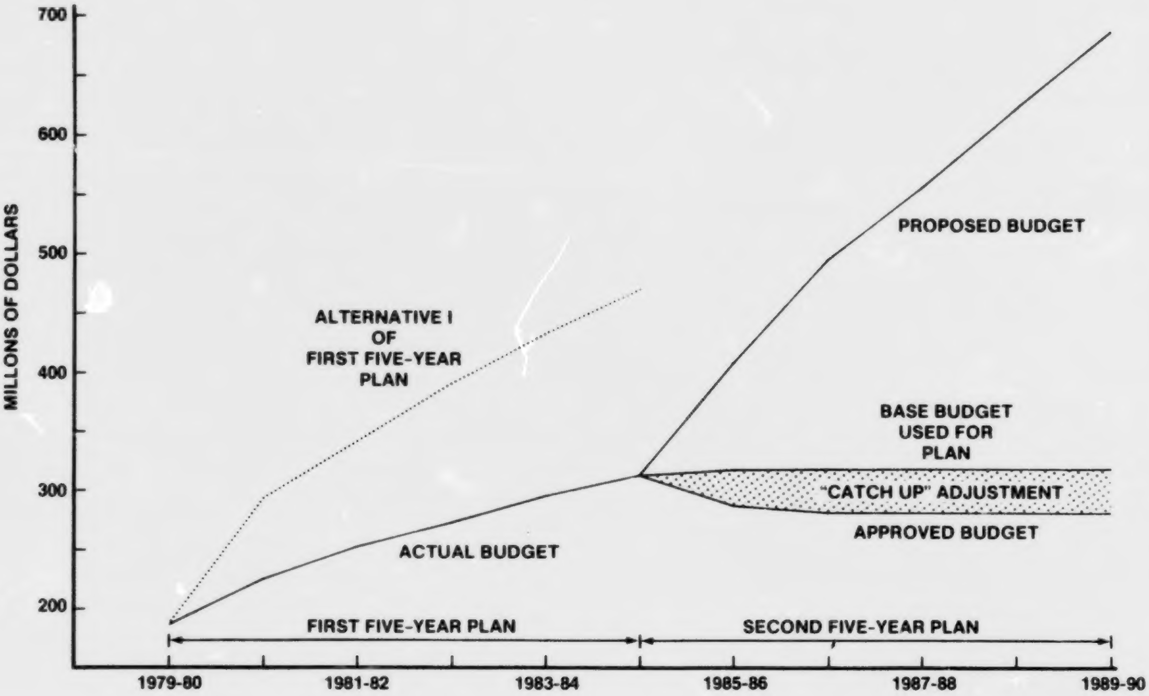


Table 64

Required Investment for the Recommended Plan of Action
(millions of **constant** 1984-85 dollars)

	Second Five-Year Plan					Total additional investment required
	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90	
(a) Approved Budgets	287.1	280.8	280.5	280.5	280.5	
(b) "Catch up" adjustment	29.1	35.4	35.7	35.7	35.7	
(c) Base budget used for Plan	316.2	316.2	316.2	316.2	316.2	
(d) Increments required	93.6	187.0	248.7	317.6	386.7	
(e) Total budget proposed in Plan	409.8	503.2	564.9	633.8	702.9	
- Total increase required [(b) + (d)]	122.7	222.4	284.4	353.3	422.4	1405.2
- Annual A-Base increments: Year 1	122.7--------	----------	----------	----------	----------	
Year 2		99.7--------	----------	----------	----------	
Year 3			62.0--------	----------	----------	
Year 4				68.9--------	----------	
Year 5					69.1	

Figure 45

Required Investment for the Recommended Plan of Action
(millions of current dollars)

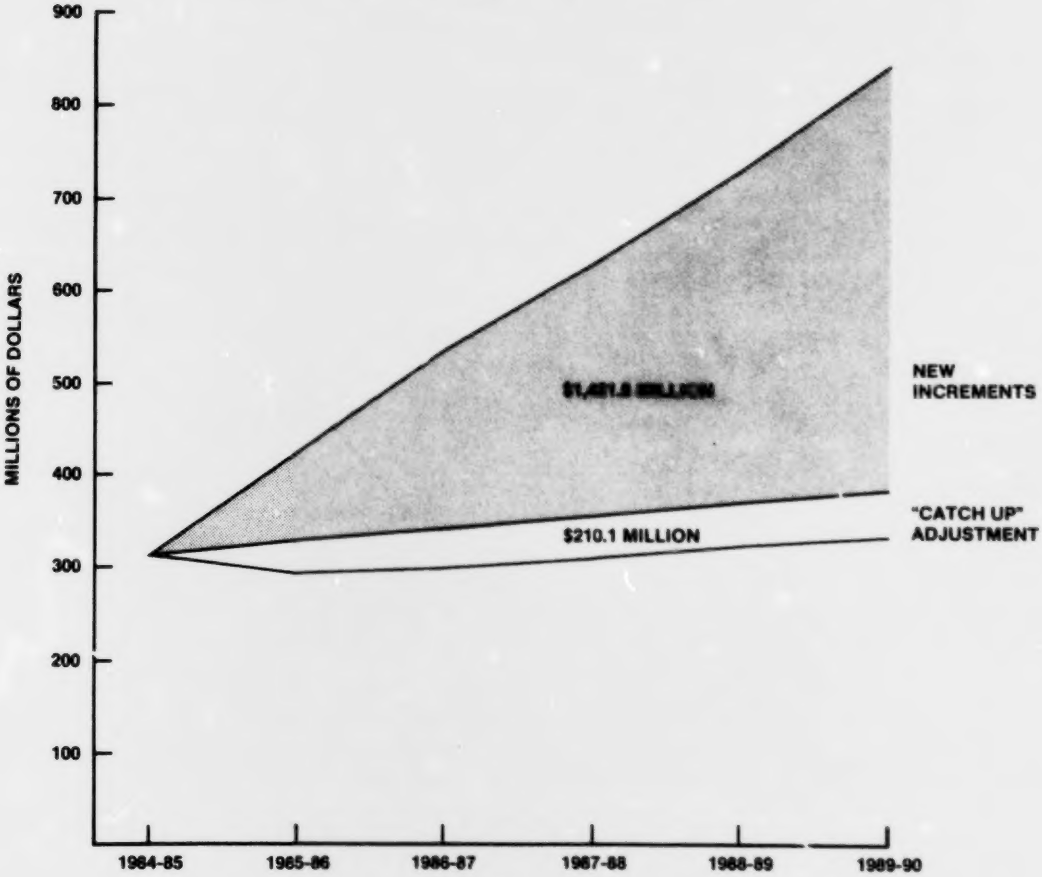


Table 65

Required Investment
(millions of current dollars)

		Second Five-Year Plan (1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90	Total additional investment required
(a) Approved Budgets		295.5	300.6	312.3	324.8	337.8	
(b) "Catch up" adjustment		33.3	41.4	43.4	45.1	46.9	
(c) Base budget used for Plan		328.8	342.0	355.7	369.9	384.7	
(d) Increments required		97.4	202.3	279.7	371.6	470.5	
(e) Total budget proposed in Plan		426.2	544.3	635.4	741.5	855.2	
- Total increase required [(b) + (d)]		130.7	243.7	323.1	416.7	517.4	1631.6
- Annual A-Base increments:	Year 1	130.7----------	----------	----------	----------	----------	
	Year 2		113.0----------	----------	----------	----------	
	Year 3			79.4----------	----------	----------	
	Year 4				93.6----------	----------	
	Year 5					100.7	

Table 66

Incremental Investment Components for the Next Five Years
(millions of constant 1984-85 dollars)

	Second Five-Year Plan					
	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90	Totals(1)
Completing the First Plan	29.1	35.4	35.7	35.7	35.7	171.6
Pursuing the Second Plan	93.6	187.0	248.7	317.6	386.7	1233.6
Total Incremental Investment Required	122.7	222.4	284.4	353.3	422.4	1405.2

---

(1) The right hand column totals for the five years in current dollars are \$210.1, \$1,421.5, and \$1,631.6 million respectively.

It must be emphasized that almost 12.2% of the incremental investment being called for is required just to maintain the proposed 1984-85 level of NSERC's programs. Because this level of funding is not now assured, NSERC is entering fiscal year 1985-86 with:

- no funds available for equipment;
- a **backlog** of highly recommended but unfunded equipment requests involving \$23 million;
- no funds to cover the impact of inflation on multi-year grants or scholarships;
- no funds for the increased numbers of scholarships or fellowships that are clearly essential;
- funding for Strategic Grants equal to only about 15% of expected applications;
- no Council reserve; and
- no funds for new University-Industry initiatives after July.

The message therefore should be very clear: the uncertainty and lack of continuity that has plagued the first Plan should be corrected by approving an ongoing annual budget of \$316.2 million (constant 1984-85 dollars) for those initiatives. This second Plan must then be assessed and funded on the merits of the case presented by this document. The two components should not be thrown together; they are separate and distinct parts of the total investment package and should be addressed in that way by whatever funding decision is forthcoming.

A Possible Modification

The Recommended Plan of Action presents what Council feels should be pursued over the next five years if the university community is to make an essential input into the national R&D effort. However, it is recognized that elements of the proposed activities would take this federal granting council further into the support of some activities that have historically been funded in part by the universities themselves from provincial grants.

The resultant dilemma is as follows:

- provincial grants to universities have fallen well behind enrolment and R&D growth rates (Figure 29, Page 125);
- universities are moving funds away from R&D support to meet undergraduate enrolment pressures;
- services that are absolutely essential for good research and research training are now sadly deficient;
- NSERC has quantified some critical elements of that need and is proposing funding through this second Plan;
- if those needs are funded through NSERC it will only serve to increase further the growing percentage of total university costs being met from federal funding (direct and through fiscal transfers to the provinces);
- however, if those needs are not met by NSERC the whole research effort at the universities will suffer.

Pending what hopefully will be an early federal-provincial agreement on a new approach for the overall support of postsecondary education and research in Canada, Council understands that there could be some reluctance to see NSERC's initiatives further alter the current funding balance. Accordingly, this second Plan has identified two programs that represent the major moves in that direction; the expanded Infrastructure activity and the program of Research Professorships. If the federal government wished to hold NSERC closer to what has been its "Traditional Mandate", then these two programs would be the logical ones to be deferred pending a new federal-provincial agreement. Unfortunately, however, they are key elements of the second Five-Year Plan and the overall research effort at the universities will suffer severely if the requirements they represent are not met from some source at an early date.

A move back from the "Expanded Mandate" represented by the Recommended Plan of Action to a more "Traditional Mandate" would result in an investment reduction of over $100 million a year (constant 1984-85 dollars) by the end of the Five-Year Plan. Table 67 documents this "saving" and the resultant investment levels for each of the five years. **It is a "saving", however, that NSERC cannot recommend.**

Table 67

Reduced Investment Levels Associated with a "Traditional Mandate"
(millions of constant 1984-85 dollars)

	Second Five-Year Plan				
	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90
Recommended Plan of Action	409.8	503.2	564.9	633.8	702.9
Less:					
a) Research Professorships	8.8	14.1	19.4	24.7	30.0
b) Expanded Infrastructure	24.0	52.8	58.1	63.9	70.3
c) Reduced Associated Costs	1.0	2.1	2.4	2.5	3.0
d) Total Reduction	33.8	69.0	79.9	91.1	103.3
"Traditional Mandate" Investment Levels:					
- constant dollars	376.0	434.2	485.0	542.7	599.6
- current dollars	391.0	469.6	545.6	634.9	729.5

Adoption of the "Traditional Mandate" approach would reduce the **incremental** investment needs over the next five years by $377 million (constant 1984-85 dollars) or by $432 million (current dollars). This represents a 31% reduction in the new investments associated with the second Five-Year Plan ($1,233.6 million constant 1984-85 dollars) and a 27% reduction in the total new investment being requested for the combined first and second Plans ($1405.2 million constant 1984-85 dollars). The resultant annual increments of funding entailed are given by Table 68.

Table 68

Increments of Funding Associated with a "Traditional Mandate"
(millions of constant 1984-85 dollars)

	Second Five-Year Plan					
	(1) 1985-86	(2) 1986-87	(3) 1987-88	(4) 1988-89	(5) 1989-90	Five-Year Totals
Completing the First Plan	29.1	35.4	35.7	35.7	35.7	171.6
Pursuing this Second Plan	59.8	118.0	168.8	226.5	283.4	856.5
Totals:						
- constant dollars	88.9	153.4	204.5	262.2	319.1	1028.1
- current dollars	95.5	169.1	233.2	310.1	391.7	1199.6

Other Alternatives

Any number of possible fall-back positions could, of course, be developed and costed. However, none of them would be at all compatible with either the assessment of need developed by this Plan or the federal government's stated objectives for a greatly increased R&D effort. Accordingly, none is presented. If the recommended funding levels are not forthcoming, the Council itself will have to assess what is possible as opposed to what is required. That can only be done properly at the time of a funding decision and with due consideration of the degree of continuity associated with that funding.

Putting It All Into Perspective: A Few Comparisons

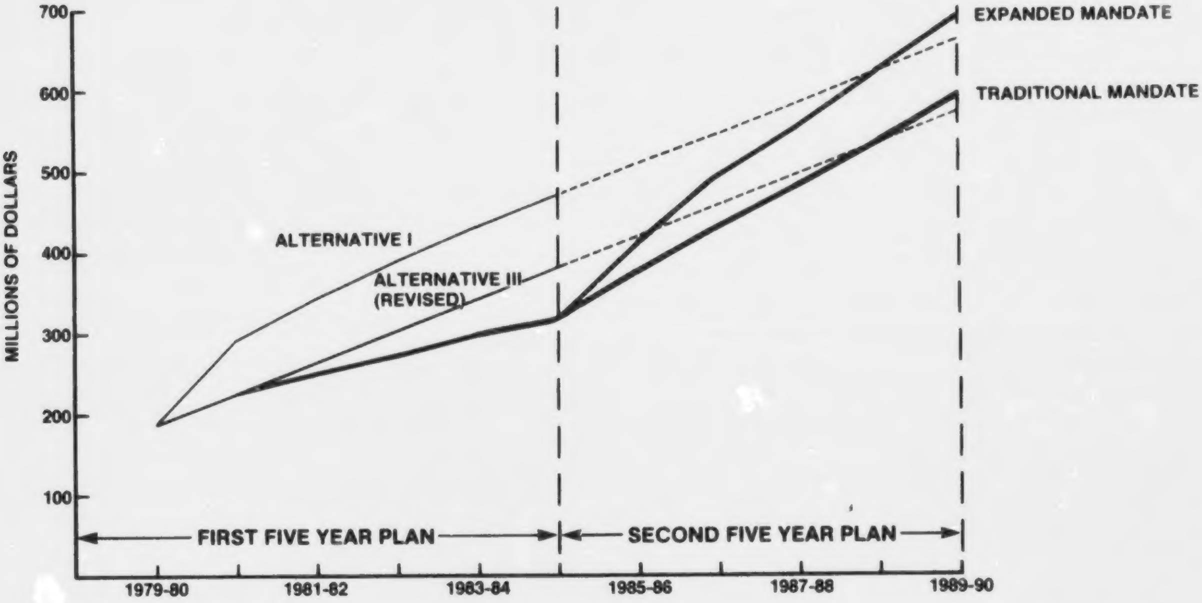
The Council is very cognizant of the magnitude of the funding request associated with the Recommended Plan of Action, especially given the move to restrict federal government expenditures and to get the overall budget deficit under control. However, economic growth must be stimulated as part of the overall fiscal plan, and research and development and human resources have been specifically identified as key ingredients of such growth. Given the very fundamental role played by the university sector in both research and research training, the Council is of the view that this Plan must go forward with its strong endorsement; it is a prerequisite for the government's repeated targets for increased R&D and for economic growth premised on "R&D, innovation and technology diffusion".

NSERC's programs should no longer be premised on what has happened in the past; rather they must be assessed in the context of those future challenges. While this document has concluded that the federal government's R&D targets are not realizable by 1990 because of a shortage of research talent, that does not mean that the targets themselves are unreasonable; only that it is going to take longer to achieve them. If they are **ever** to be achieved, however, several actions are required immediately in the areas of education and specific research training. The initiatives proposed by this second Five-Year Plan are based on the established, well-proven and highly-accepted programs of NSERC and represent an urgent investment opportunity for the federal government. Given the key role they play in providing for the future of R&D in Canada, their rejection would be tantamount to a rejection of not only the national targets, but also of the economic activity that can only come from a more sophisticated and technologically-oriented society. Surely that option of retreat is not a valid one even in today's environment of fiscal restraint.

It is also useful to stand back and take a fresh look at NSERC's efforts and proposals in a broader context. First of all the degree of proposed growth should not come as a surprise. The challenges were already visible in 1979 and were addressed by the first Plan; the fact that the required resources were not forthcoming has not removed that need. Figure 46 compares an extension of funding trends recommended in 1979 to the proposals contained in this new Plan.

Figure 46

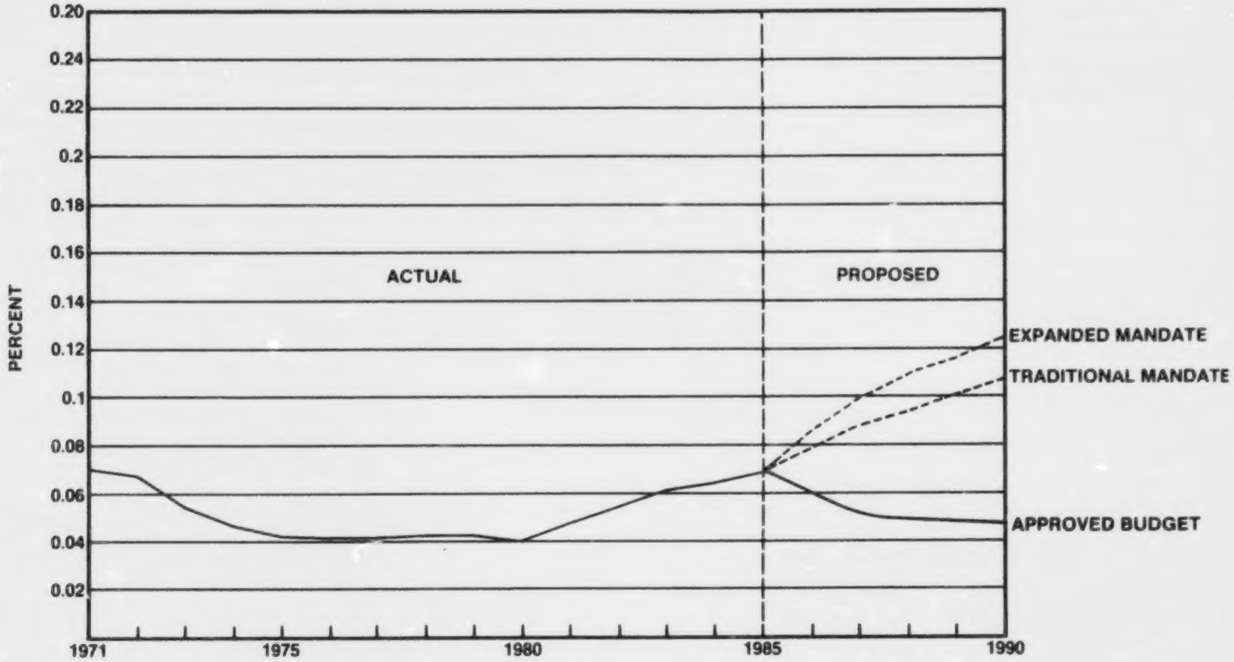
Comparison of Various Investment Projections
(millions of constant 1984-85 dollars)



A comparison of NSERC funding to total Gross National Product is also a good indicator of the degree of priority being sought for this effort. Such a comparison is given by Figure 47. Even with the growth projected, Canada would still lag well behind the **current** levels of investment in university-based R&D of our OECD competitors.

Figure 47

NSERC Program Budget as a Percentage of GNP



Within the total spectrum of the federal government's R&D support mechanisms the incremental investment being sought over the next five years equates roughly to the recent federal "contribution" through the now suspended program of Scientific Research Tax Credits. While it is recognized that increased industrial R&D activity was the end objective of that program, and that the financial obligation greatly exceeded planned levels, the comparison still has some merit. NSERC's proposals will provide the vital human resources for all research needs, including industry's. A community of some 30,000 individuals from coast to coast will benefit from NSERC's programs through support of their research or through some degree of salary support.

Finally, one should close the circle by returning to the Preface and the Introduction of this document wherein both NSERC and an eminent industrial leader are quoted with regard to our increasing dependence on our intellectual capital as opposed to our historic reliance on our physical resources. It is a position espoused by many, and was reflected in the "Economic Statement" by the federal Finance Minister on November 8, 1984. And yet, over the past half decade, the increased funding achieved by NSERC for university research has only been realized with great difficulty through a series of requests that were time consuming for the Council and no doubt annoying for Ministers because of their frequency. The staccato nature of the process and of the resultant funding decisions (Figure 2, Page 6) certainly does not match in any way the commitment suggested by repeated policy statements.

During these past five years NSERC was able to achieve a cumulative real increase in its budget of almost $415 million (constant 1984-85 dollars), but almost half of that came from the first decision taken back in 1979. During that same five-year period the ongoing resource psyche of this nation is reflected in the multi-billion dollar commitment to frontier exploration through the Petroleum Incentives Program (PIP) of Energy, Mines and Resources, Canada. **The incremental investment being sought for by this Plan over the next five years for the existing and future research talent of this country is indeed impressive and well beyond past experience; however, the total five-year incremental investment is $200 million less in real terms than the one-year investment in frontier exploration through PIP in 1983-84 alone.**

NSERC contends that that is the context within which this Plan should be assessed; are we really prepared as a nation to decrease our overwhelming dependence on depleting physical resources and to turn our attention increasingly towards a world where we must survive largely on the basis of our intellectual capacity? That will be the test of this Plan, and that will also be a critical test of this nation and its resolve to start that change of emphasis. This Plan is very much part of the process of laying down the foundation and preparing the way; it is very much "The Bridge to the '90s".

Completing the Bridge to the 90's

A SECOND FIVE-YEAR PLAN FOR THE PROGRAMS
OF THE
NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL

COMPLETING THE BRIDGE TO THE 90's

APPENDICES

June 1985

Ottawa, Ontario

(disponible en français
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APPENDIX I

RESEARCH MANPOWER PROGRAMS

SECTION A - RESEARCH MANPOWER PROGRAMS - 1980 TO 1985

A-1 Undergraduate Summer Research Awards

A-1.1 Program Objectives and Description

This program consists of two similar components: the university component and the industry component.

The objectives of this program are to stimulate the interest of undergraduate students in research by providing them with valuable experience in an industrial or university laboratory and to encourage them to undertake graduate studies.

Through the university component of this program undergraduate students may spend up to four months during the summer (or during a work-term for co-op students) working on a research project under the supervision of a faculty member at a Canadian university. Students may apply for one of these awards at any eligible Canadian university and are not restricted to remaining at their own institution. Each eligible university is given a quota of awards. The quota is related to the total value of certain types of NSERC research grants which have been awarded to that university in a previous year. Universities may allocate their quota of awards to students as they see fit, provided that the students satisfy certain NSERC criteria, including academic record. NSERC provides a stipend of $750 per month to the student. The universities may (and usually do) supplement these stipends from other sources.

The industry component is similar to the university component in that the students work on a research project in industry for up to four months during the summer (or during a work period). Companies must satisfy certain NSERC criteria to be approved for participation in this program. These criteria essentially require that the company be incorporated in Canada, be engaged in appropriate technological activities and be able to exploit their research results to the benefit of Canada. Students wishing to apply for one of these awards contact the company of their choice and, if it wishes to accept the student, the company submits a nomination to NSERC. As before, the students must satisfy NSERC criteria, mainly relating to academic record. NSERC makes a contribution of $750 per month towards the student's salary. The company may (and usually does) pay a higher salary to the student.

A-1.2 Experience to Date

This program was introduced in early 1980. The first awards in the university component were held in the summer of 1980 and the first industry awards were held during the summer of 1981. The numbers of awards held each year to date are shown in Table I.1.

TABLE I.1

Undergraduate Summer Research Awards Held

Year	University	Industry	Total
1980-81	1000	-	1000
1981-82	981	126	1107
1982-83	1444	248	1692
1983-84	1494	403	1897
1984-85*	2000	500	2500

* 1984-85 figures subject to small changes.

The quota of university awards for each eligible institution in 1984-85 is shown in Table I.2.

TABLE I.2

Undergraduate Summer Research Award Quotas for 1984-85

UBC	156
Simon Fraser	41
Victoria	33
Alberta	115
Calgary	66
Lethbridge	11
Saskatchewan	56
Regina	12
Manitoba	63
Brandon	8
Winnipeg	9
Brock	15
Carleton	45
Guelph	85
Lakehead	13
Laurentian	11
McMaster	85
Ottawa	46
Queen's	63
Toronto	197
Trent	9
Waterloo	103
WLU	9
Western	66
Windsor	29
York	38
Bishop's	8
Laval	52
McGill	103
Montréal	56
Ecole Poly.	33
Sherbrooke	29
Concordia	32
UQ Montréal	11
UQ Chicoutimi	11
UQ T. Rivières	16
UQ Rimouski	8
INRS	21
Inst. A. Frappier	8
Moncton	9
Mt. Allison	9
UNB	36
St. Thomas	8
Acadia	11
Dalhousie	48
Mt. St. Vincent	8
TUNS	16
St. F. Xavier	11
St. Mary's	9
NSAC	8
Cape Breton	8
PEI	8
Memorial	42

As of December 1984, a total of 758 companies were eligible to participate in the industry component of this program. The number of companies actually hiring students through this program has increased steadily each year as shown in Table I.3.

TABLE I.3

Number of Companies Hiring Students by Province and Year

	1981-82	1982-83	1983-84	1984-85
British Columbia	3	12	13	14
Alberta	3	2	4	8
Saskatchewan	1	0	0	1
Manitoba	0	0	0	6
Ontario	39	57	88	114
Québec	9	17	30	31
New Brunswick	1	2	0	0
Prince Edward Island	1	1	1	1
Nova Scotia	2	0	2	1
Newfoundland	0	0	0	1
Northwest Territories	0	1	1	0
	59	92	139	177

The number of universities whose students participated in the industry component of this program in 1984-85 was 35. The number of students per university taking advantage of this scheme ranged from 1 to 131 with the average being about 13. The students were registered in a wide range of programs with the largest groups being from engineering (226), chemistry (77) and biological sciences (76).

A-1.3 Evaluation of Program

An evaluation of the undergraduate summer research awards program by independent consultants has indicated that this program is meeting its objectives and is strongly favoured by those involved, both students and supervisors. Among the results of a survey conducted by the consultants are the following:

(a) 94% of the supervisors of the students (both in industry and in universities) stated that the students had made a real contribution to their research efforts;

(b) 80% of the students plan to attend graduate school and 64% felt that the work experience through this program had had an influence on their decision to attend graduate school;

(c) over 85% of the students were satisfied with their experience gained through this program and 78% reported that this experience had increased their interest in research and development;

(d) 79% of the supervisors of students in industry stated that there had been a benefit to their company that could be attributed, at least in part, to the student's work.

A-2 Postgraduate Scholarships

A-2.1 Program Objectives and Description

The objective of this program is to assist in the provision of highly qualified manpower by providing financial support to excellent students working towards a higher degree in the natural sciences and engineering.

Applicants must be Canadian citizens or permanent residents of Canada. They apply for these awards through their university, if they are currently attending a Canadian university, or directly to NSERC if they are currently employed or are attending a university in another country. Applicants must plan to undertake study for a master's or doctoral degree in one of the fields covered by NSERC's mandate.

Applications received by Canadian universities are screened and ranked internally by the university. Those recommended by the university for an award are subsequently considered by an NSERC selection committee. Those not recommended by the university are not considered further. All applications submitted directly to NSERC are assessed by the NSERC selection committee. There are no quotas by discipline or by university. All applications are considered solely on their merits and awards are made only to students having first class records.

NSERC postgraduate scholarships are normally tenable only at Canadian universities but permission to hold a scholarship at a foreign university may be granted if it can be shown that the proposed study and research program is not offered at a Canadian university.

The present value of these awards is $11,600 per year. Scholars may accept other, non-federal, scholarships without restriction and may undertake a limited amount of duties, such as teaching, provided that this work will not hinder the progress of their studies.

A-2.2 Experience During Past Five Years

The past five years has been a period of sustained growth of the NSERC Postgraduate Scholarships program. This growth has been a major factor in the rejuvenation of the graduate programs at Canadian universities in all of the disciplines which fall within NSERC's mandate. The nature of this growth is illustrated in Table I.4. This table gives figures for the major disciplines, or discipline groups, showing the numbers of new or renewal scholarships offered each year, the number held that year, the number declined, the number deferred for possible use later, the number of the deferred awards which were actually taken up during the allowable period of two years, and the total number of awards which were eventually declined.

TABLE I.4

Postgraduate Scholarships Offered, Held, Declined and Deferred by Discipline and Year

Discipline	Year	Offered	Held	Declined	Deferred	Deferred Then Held	Total Eventually Held
Biological Sciences	1980	529	417	76	36	18	435
	1981	599	459	94	46	29	488
	1982	604	466	84	54	24	490
	1983	698	562	86	50	N/A	N/A
	1984	736	678	34	24	N/A	N/A
Chemistry	1980	193	172	6	15	7	179
	1981	207	183	17	7	4	187
	1982	200	183	11	6	3	186
	1983	237	212	18	7	N/A	N/A
	1984	222	209	10	3	N/A	N/A
Computer Science	1980	110	84	5	21	10	94
	1981	135	111	6	18	10	121
	1982	145	112	11	22	3	115
	1983	188	136	20	32	N/A	N/A
	1984	224	190	12	22	N/A	N/A
Earth Sciences	1980	84	68	6	10	8	76
	1981	71	56	4	11	8	64
	1982	97	84	7	6	2	86
	1983	124	106	12	6	N/A	N/A
	1984	127	114	5	8	N/A	N/A
Engineering	1980	440	306	46	88	27	333
	1981	473	326	46	101	45	371
	1982	519	392	28	99	18	410
	1983	765	602	61	102	N/A	N/A
	1984	792	691	41	60	N/A	N/A
Mathematics	1980	151	122	10	19	10	132
	1981	154	126	14	14	12	138
	1982	182	148	28	6	4	152
	1983	176	160	11	5	N/A	N/A
	1984	199	182	14	3	N/A	N/A
Physics	1980	230	198	15	17	9	207
	1981	277	244	18	15	7	251
	1982	265	230	20	15	6	236
	1983	311	271	33	7	N/A	N/A
	1984	325	309	12	4	N/A	N/A
Psychology	1980	119	109	9	1	1	110
	1981	134	119	11	4	3	122
	1982	157	138	14	5	2	140
	1983	180	163	13	4	N/A	N/A
	1984	178	161	13	4	N/A	N/A

Notes: The figures given in this table refer only to new and renewal awards. Reinstated awards which had been deferred in previous years are not included.

A small number of awards in other disciplines are not included in this table.

The 1984 figures are not yet final and are subject to small changes.

It is particularly interesting to note that the greatest percentage growth in numbers of awards held has occurred in Computer Science, Earth Sciences and Engineering, three fields in which the numbers of Canadian graduate students have been alarmingly low in the past.

The distribution of NSERC postgraduate scholars in 1984 by place of tenure is shown in Table I.5. These figures were not quite final as of the time of writing but any changes are unlikely to be significant. It is seen that 89.6% of these scholarships were held in Canada, 8.4% in the United States and 2.0% in other countries. Within Canada, awards were held at 39 different institutions. The number of Canadian universities whose students were offered awards was 52. The difference is due principally to the fact that there is a group of universities which do not offer graduate programs.

A-2.3 Evaluation of Program

The evaluation of the NSERC postgraduate scholarships program by independent consultants has shown that this program is meeting its objectives. The survey conducted by the consultants showed that:

(a) 95% of departmental chairmen surveyed were of the opinion that these scholarships were awarded to excellent students;

(b) 93% of students who completed their NSERC scholarship support in 1975-76 had worked in at least one position involving R & D duties since that time, and 85% were in such a position in 1984.

(c) 82% of this group of former scholars are currently employed in Canada.

As indicated in section 2.2, about 10.4% of the 1984 scholarships are held abroad. It is of interest to predict what fraction of these 270 or so scholars will ultimately return to Canada to pursue their professional careers. The consultants surveyed 28 persons who had held NSERC postgraduate scholarships abroad and who completed their scholarship support in 1975-76. Of these, 14 (50%) are now pursuing their careers abroad. Clearly, this 50% figure cannot be assumed to apply to those students who now hold awards abroad. The likelihood of these students to return to Canada will depend upon future economic conditions, and upon the availability in the future of interesting and challenging employment opportunities. The year 1976-77 was a time when the GERD/GNP ratio was at its lowest at any time from 1963 to the present. It was a time when the NSERC budget as a percentage of GNP was at or about its

TABLE I.5

Place of Tenure of NSERC Postgraduate Scholars in 1984-85

UBC	175	Queen's	91	UQ Rimouski	2
Simon Fraser	45	Toronto	363	UQ T. Rivières	18
Victoria	24	Trent	1	UQ IAF	2
Alberta	92	Waterloo	204	UQ INRS	14
Calgary	51	Western	68	UNB	48
Saskatchewan	41	Windsor	17	Mt. Allison	1
Regina	6	York	18	Acadia	2
Manitoba	95	Laval	133	Dalhousie	32
Brock	1	McGill	189	TUNS	12
Carleton	51	Montréal	129	St. Mary's	2
Guelph	89	École Polytechnique	40	Memorial	17
Lakehead	3	Sherbrooke	35	CANADA TOTAL	2332
Laurentian	2	Concordia	37	USA	219
McMaster	89	UQ Montréal	26	OTHER TOTAL	53
Ottawa	65	UQ Chicoutimi	2		

Note: The above figures are not yet final and are subject to small changes.

lowest value since 1966. It seems likely that, with the anticipated need during the next decade to replace large numbers of retiring faculty members, and if the expected increase in the GERD/GNP ratio takes place, there will be an abundance of positions available in Canada for those scholars who are studying abroad. Hence, the 50% figure noted by the consultants is unlikely to occur in the future. A much smaller proportion can be expected to remain abroad during the next decade.

A-3 1967 Science and Engineering Scholarships

A-3.1 Program Objectives and Description

The objective of this program is to enable outstanding students to undertake graduate studies and research leading to a doctorate and to take advantage of the best possible training opportunities in Canada or abroad.

These scholarships are prestigious awards which are given to a maximum of 60 students each year following a rigorous selection process. Candidates do not apply on their own initiative for these scholarships but are invited by their universities to submit applications. The universities select these nominees from among the best of their applicants for first year NSERC postgraduate scholarships. The applications of these candidates are initially reviewed by a special NSERC selection committee which choses a number for interview. Interviews are held in Montreal, Toronto and Vancouver. The selection committee bases its decisions upon the applicant's academic record, potential for scientific leadership, ability to communicate verbally and in writing, and general knowledge and interests.

The 1967 science and engineering scholarships are tenable at any university, in Canada or abroad. Their current value is $17,500 per year.

A-3.2 Experience During Past Five Years

During the past five years there have been no major changes in this program. The name of the scholarship was broadened to include engineering in 1983 (engineers had always been eligible for these awards) and the number of available new scholarships each year was increased from 50 to 60 in 1984. Perhaps the most significant change was the decision made in 1983 to allow these awards to be held abroad without any special justification by the student. This change came about because of the observation that many students who were recipients of these scholarships declined to accept them because of a strong desire to study at a leading institution abroad. These students, because of their high calibre, were able to obtain scholarships from foreign universities. The Council has taken the view that, if a Canadian student undertakes postgraduate studies at a foreign university with a Canadian scholarship, there is an increased probability that the student will wish ultimately to return to Canada.

The distribution of 1967 Science and Engineering scholars in 1984 by place of tenure is shown in Table I.6. These figures are subject to minor changes. It is seen that 59% of these awards are held in Canada, 36% in the USA and 5% in other countries.

The university of undergraduate study for the 60 scholarship winners in 1984 is shown in Table I.7.

A-3.3 Evaluation of Program

According to the consultants who evaluated this program:

> "The 1967 scholarships program achieves all of its objectives. The scholarships are indeed awarded to outstanding students, most of whom successfully undertake graduate studies and research leading to a doctorate. Most 1967 scholars take advantage of the best possible training opportunities for their field of study."

In support of the above conclusion, the consultants reported that, based upon their survey:

(a) 83% of departmental chairmen and 95% of university administrators were of the opinion that 1967 Science and Engineering scholarships were awarded to the most outstanding students;

(b) 94% of the scholars who completed their scholarship support in 1976-77 have completed their Ph.D. degrees.

In addition, the consultants found that:

(c) 95% of students who completed their 1967 Science and Engineering scholarships in 1976-77 had worked in R & D at some point since that time, and 86% were in such a position in 1984;

(d) 86% of this group of former scholars are currently employed in Canada.

TABLE I.6

Place of Tenure of 1967 Science and Engineering Scholarships in 1984-85

UBC	5	Western	3	Cornell	5
Simon Fraser	1	York	1	Princeton	4
Victoria	2	Laval	2	Stanford	5
Alberta	6	McGill	10	Yale	4
Manitoba	1	Montréal	1	Other USA	22
Carleton	3	École Polytechnique	1	USA TOTAL	50
Guelph	1	Sherbrooke	2	Cambridge	4
Lakehead	1	Concordia	2	Other Europe	4
McMaster	4	UQ INRS	2	EUROPE TOTAL	8
Ottawa	4	UNB	1	GRAND TOTAL	140
Queen's	3	Dalhousie	4		
Toronto	13	CANADA TOTAL	82		
Waterloo	9	Berkeley	10		

TABLE I.7

University of Undergraduate Studies for 1984 Winners of 1967 Science and Engineering Scholarships

UBC	4	McMaster	2	École Poly.	1
Simon Fraser	2	Ottawa	1	UQ T. Rivières	1
Alberta	2	Queen's	4	Moncton	2
Calgary	2	Toronto	3	UNB	4
Saskatchewan	1	Waterloo	6	Acadia	1
Manitoba	2	Laval	6	Dalhousie	2
Winnipeg	3	McGill	6	TUNS	1
Carleton	2	Montréal	1	Memorial	1

The consultants were able to survey only 7 persons who had held these awards abroad. They found that 4 were now employed in Canada and 3 abroad. It should be noted that the regulation governing tenure of these awards abroad has changed relatively recently. Hence, it is to be expected that the fraction now holding awards abroad will be higher than was the case in 1976-77. The remarks made in section 2.3 concerning the likelihood of regular postgraduate scholarship holders to return to Canada apply also to the 1967 science and engineering scholars. However, because these scholars are a very select group there does exist the possibility that international competition for their services may cause a higher fraction to remain abroad.

A-4 Postgraduate Scholarships in Science Librarianship and Documentation

A-4.1 Program Objectives and Description

The objective of this small program is to assist science or engineering graduates to obtain advanced degrees in the fields of science librarianship and documentation and, hence, to assist in maintaining an adequate supply of specialists in these fields.

Applicants must be Canadian citizens or permanent residents who hold or expect to receive a degree in science or engineering, and they must be accepted by a recognized school of library science and documentation as candidates for a master of library science degree. The awards are tenable for up to two years.

These scholarships include provision for successful candidates to undergo a four-month practical training period at the library of the Canada Institute for Scientific and Technical Information in Ottawa or at other approved libraries.

The present value of these awards is $11,600 per year. Scholars may accept other scholarships from non-federal sources without restriction but may not undertake any paid work.

A-4.2 Experience During Past Five Years

This program has operated at a constant level throughout the past five years. The numbers of applications, awards offered, and awards held each year are given in Table I.8. In this table, the term "total number" indicates that renewal awards are included in the figures given.

TABLE I.8

Postgraduate Scholarships in Science Librarianship and Documentstion, 1980-85

Year	Total Applications	Applications for New Awards	Total Awards Offered	New Awards Offered	Total Awards Held	New Award Held
1980-81	29	26	13	10	12	10
1981-82	21	17	14	10	11	7
1982-83	30	26	14	10	11	8
1983-84	32	30	12	10	11	10
1984-85	37	31	16	10	16	10

A-4.3 Evaluation of Program

The consultants who evaluated this program concluded that the program achieves its objective of assisting in the maintenance of an adequate supply of science librarians, documentalists and science information specialists in Canada.

As a result of their survey of library heads the consultants also concluded that:

(a) NSERC is unquestionably the major and most important source of support for graduate studies in science librarianship in Canada;

(b) NSERC has had a significant and positive impact on the supply of science librarians in Canada. Although only a few scholarships are awarded each year, the indirect impacts of NSERC's involvement in this field, according to many librarians, have made science librarianship a respectable discipline and career. The prestige of NSERC's name associated with science librarianship has also had an impact on enrolment and on the quality of graduate students being attracted to library science graduate schools;

(c) this program attracts outstanding students who, in turn, become excellent science librarians.

A-5 Industrial Postgraduate Scholarships

A-5.1 Program Objectives and Description

The objectives of this program are: (a) to encourage holders of a bachelor's or master's degree with industrial work experience to enter into a program of graduate studies and research with industrial sponsorship; (b) to enhance the research, development and innovation capability of Canadian industry in those fields of the natural sciences and engineering it wishes to pursue; (c) to develop a stronger industry/ university interface; and (d) to increase the commitment of Canadian industry to R & D and to research training in Canadian universities.

Industrial postgraduate scholarships are intended for Canadian citizens and permanent residents who, following receipt of a bachelor's or master's degree, have completed from two to six years of work experience in an approved industrial organization in Canada. By means of these awards, engineers and scientists employed in industry can return to a university to obtain a higher degree while on a leave of absence from their employer. In order to minimize the financial hardship which might be involved in returning to university for a year or more, NSERC joins with the employer in providing a reasonable level of financial support to the student. The employer is required to contribute at least $6,000 per annum. NSERC then matches the company contribution up to a maximum of $11,600 per annum. If it so wishes, the employer may contribute more than $11,600 per annum.

A-5.2 Experience to Date

The first awards of these scholarships were made in 1983 for tenure during the academic year 1983-84. To date, therefore, there has only been two years of experience with this program. Some figures to illustrate the scale of this program during its first two years are as follows:

No. of applications	34
No. of awards offered	27
No. of awards held	26
No. of sponsoring companies	19

The disciplines in which these scholars are studying are as follows:

Engineering	17
Earth sciences	4
Biological sciences	1
Chemistry	1
Computer science	1
Management science	1
Physics	1

The universities at which the scholars are studying are as follows:

UBC	1
Alberta	4
Saskatchewan	2
Manitoba	1
Carleton	2
McMaster	1
Ottawa	2
Toronto	1
Waterloo	5
École Polytechnique	4
McGill	3

The company contribution to the salary of the scholar ranges from $6,000 to $40,878 per annum.

Because of the newness of this program it was not included in the group of manpower programs which were recently evaluated by external consultants.

A-6 Postdoctoral Fellowships

A-6.1 Program Objectives and Description

The objective of this program is to provide recent doctoral graduates with an opportunity to add to their experience by engaging in a specialized training program in Canadian universities, provincial research councils, and universities and research institutions abroad.

Applicants must be Canadian citizens or permanent residents of Canada, the latter must be residing in Canada at the time of application. They must have obtained their doctorate not more than three years prior to the date of application.

All applications are submitted directly to NSERC and are evaluated by an interdisciplinary committee. There are no quotas by discipline. All applications are considered solely on their merits with an emphasis being placed upon the candidate's promise as a researcher.

The present value of these awards is $23,300 per year. Recipients may accept a limited amount of duties, such as teaching, provided that this work will not hinder the progress of their research. They may accept other, non-federal, scholarships without restriction. These awards are tenable for one year and, in certain cases, may be renewed for a second year.

A-6.2 Experience During Past Five Years

This program has experienced a substantial growth over the five-year period but this growth has not kept pace with the increase in the number of applications received. Table I.9 illustrates this situation. The 1984-85 figures are tentative and subject to small adjustments. (It should be noted that, using funds provided by NATO, about 11 additional awards have been made, on average, each year. Taking these awards into account, the success rate has varied from 43.0% in 1980-81 to 29.9% in 1984-85.)

TABLE I.9

Postdoctoral Fellowships, 1980-85

	Applications for New Awards	New Awards Offered	New Awards Held	Application Success Rate	Total Awards Held Including Renewals
1980-81	307	111	60	36.2%	139
1981-82	348	126	83	36.2	153
1982-83	359	136	92	37.9	144
1983-84	510	141	92	27.6	156
1984-85	552	155	98	28.1	165

The number of fellowships (including renewals) held, by discipline, for each of the past five years is shown in Table I.10. The relatively small numbers of fellowships held in computer science, the earth sciences, and in engineering is noteworthy. These low numbers are a consequence of several factors which include the limited number of Canadians receiving Ph.D. degrees in these fields, a generally strong employment market for Ph.D. graduates in computer science and many areas of engineering, and a career pattern in engineering which tends to result in Ph.D. graduates entering regular employment in the university or other sectors without

TABLE I.10

Postdoctoral Fellowships, by Discipline, 1980-85

	No. Awards Held					Percent of Total				
Discipline	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984
Biological Sci.	51	56	58	63	68	36.6	36.6	40.2	40.3	41.2
Chemistry	24	25	20	25	27	17.2	16.3	13.9	16.0	16.3
Computer Sci.	2	2	2	2	2	1.4	1.3	1.3	1.2	1.2
Earth Sci.	3	1	1	3	5	2.1	0.6	0.7	1.9	3.0
Engineering	4	8	2	3	6	2.8	5.2	1.3	1.9	3.6
Math/Statistics	15	12	17	14	10	10.8	7.8	11.8	8.9	6.0
Physics	29	32	30	31	31	20.8	20.9	20.8	19.8	18.8
Psychology	11	17	14	15	16	7.9	11.1	9.7	9.6	9.6

first engaging in a period of postdoctoral research.

The distribution of the fellowships held by country of tenure during 1984-85 is as follows:

Canada	41%
USA	40%
United Kingdom	8%
France	5%
Other	6%

As may be seen, many fellows utilize their postdoctoral awards to diversify their research experience by working in foreign laboratories. On their return to this country the fellows bring with them new ideas and a greater familiarity with the international research scene which is of benefit to Canada in accessing advances made in other countries.

A-6.3 Evaluation of Program

The evaluation of the NSERC postdoctoral fellowship program by independent consultants concludes, in part, that the program assists in the development of highly trained, high quality manpower and that it assists in the maintenance and development of research in Canada. Some specific findings by the consultants are as follows:

(a) 88% of former postdoctoral fellows who held their awards abroad have returned to work in Canada;

(b) 98% of current fellows agreed that the program was providing them with an opportunity to gain valuable research skills;

(c) 82% of former postdoctoral fellows agreed that work as a fellow gave them the experience they needed to pursue a career as an independent researcher;

(d) 96% of former fellows have worked in research and development at some point since completing their fellowship;

(e) 93% of university department chairmen surveyed agreed that NSERC awarded postdoctoral fellowships to "worthy" candidates.

A-7 University Research Fellowships

A-7.1 Program Objectives and Description

The objectives of this program are to expand the career opportunities for a select number of very promising researchers in the natural sciences and engineering, to assist in maintaining the level of the university research and development effort in Canada, and to assist in maintaining an adequate supply of promising and highly qualified researchers in Canadian universities to help meet the demand for new faculty appointments which is expected to expand rapidly in the early 1990s when the retirement rate of the existing research force increases significantly and when student enrolments are projected to grow.

University Research Fellows are selected each year through a stringent competition which, typically, has a success rate of only 25%. Candidates are selected by universities and nominated by them for consideration by the selection committee. Nominees must be Canadian citizens or permanent residents of Canada, must hold, or expect to hold, a doctorate and must have relevant experience to the extent normally required for appointment at the rank of assistant professor in the same discipline. There are no award quotas by discipline or by university.

Successful nominees are given limited-term appointments by the universities. These appointments, as far as university regulations will permit, are intended to be faculty positions with all the normal privileges of such positions. Initial appointments are for three years. During this period NSERC provides a substantial subsidy (currently up to $30,500 per annum) towards the cost of the Fellow's salary and fringe benefit costs. The university, for its part, must contribute a minimum of $4,000 towards the salary and fringe benefit costs, must pay the Fellow a salary which is similar to that of other faculty members with similar qualifications and experience, and must provide adequate space, basic facilities and services to the Fellow. The Fellow receives a research grant for each of these first three years. It is expected that the Fellow will devote the majority of his or her time to independent research, including supervision of graduate students, but a limited amount of teaching may also be undertaken.

During the third year of the award, the performance of each Fellow is reviewed by the university in accordance with their normal procedures for assessment of faculty members and a recommendation is made to NSERC which either supports a further two-year appointment or termination of the appointment. The NSERC selection committee, as well as the relevant grant selection committee, also reviews the research accomplishments of the Fellow at this time. Ultimately, a decision is made by NSERC to either extend the fellowship for another two years or to terminate it. Extension for a further two years is accompanied by a further two-year research grant, and NSERC continues its salary subsidy to the university for this period.

It is NSERC's wish to see as many as possible of the fellows integrated eventually into the regular faculty of the universities. To this end, NSERC offers an incentive to the universities to offer tenure-track appointments to Fellows. In the event that a university appoints a Fellow to a tenure-track position during the period between the completion of the first three year appointment up to the end of the fifth year, NSERC will provide further salary subsidization on a gradually diminishing scale for five years from the date of the tenure-track appointment. This incentive applies equally whether the Fellow receives a tenure-track appointment from his or her own university or from some other Canadian university.

A-7.2 Experience to Date

This program was initiated in 1980 and there have been five groups of Fellows appointed during the Five-Year plan period.

The numbers of nominations, nominees, offers of fellowships, and fellowships actually held are given for each of the first five competitions in Table I.11.

TABLE I.11

University Research Fellowships, Nomination and Awards 1980-84

	1980	1981	1982	1983	1984	Total
Nominations*	366	323	274	284	259	1506
Nominees*	345	288	232	257	217	1339
Awards Offered	100	75	62	57	62	356
Awards Held	94	66	50	54	52	316

* Some individuals were nominated by more than one university.

A breakdown of the awards held by discipline of the nominating department is given in Table I.12. It may be seen that the disciplines with the largest number of Fellows are the biological sciences, physics/astronomy, and engineering. The large number of Fellows in the biological sciences is a reflection of the relatively large number of

TABLE I.12

University Research Fellowships Held, by Discipline, 1980-84

Discipline	1980	1981	1982	1983	1984	Total
Biological Sciences	24	20	16	20	18	98
Chemistry	13	5	2	6	7	33
Computer Science	1	1	1	0	0	3
Earth Sciences	2	6	4	2	3	17
Engineering	17	10	8	8	8	51
Management Science	1	0	1	0	0	2
Math/Statistics	12	8	4	3	5	32
Physics/Astron	16	11	11	9	8	55
Psychology	8	5	3	6	3	25

Ph.D.s being granted in this broad area combined with a limited number of appropriate employment opportunities at the present time. By means of this program, one is buying time for these individuals with the hope that, within the next few years substantial numbers of positions will become available.

A breakdown of the awards held by university is given in Table I.13. The figures given in this Table correspond to the university at which Fellows initially held their awards. A substantial number of Fellows subsequently accept tenure-track positions at other universities, transfer their awards to a different university, or leave the university system altogether.

TABLE I.13

University Research Fellowships Held, by University, 1980-84

UBC	15	Laurentian	1	École Poly.	8
Simon Fraser	8	McMaster	14	Sherbrooke	7
Victoria	7	Ottawa	7	Concordia	6
Alberta	15	Queen's	17	UQTR	3
Calgary	12	Toronto	47	INRS	1
Lethbridge	2	Waterloo	17	Inst. A. Fr.	1
Saskatchewan	5	W. Ontario	13	Mt. Allison	1
Regina	2	Windsor	1	UNB	4
Manitoba	15	York	10	Dalhousie	11
Brock	1	Laval	6	St. F. Xavier	2
Carleton	7	McGill	19	St. Mary's	2
Guelph	12	Montréal	13	Memorial	4

A sizeable proportion of those who have accepted University Research Fellows are persons who were abroad at the time of their nomination. For the first 5 competitions 97, or 31%, of the 316 Fellows were in this category. This program has become an important inducement to highly qualified Canadians living abroad to return home and assist in strengthening the Canadian academic research effort.

As the end of their first five-year appointment approaches, substantial numbers of the 1980 group of Fellows are being integrated into permanent university positions and some have accepted positions with Canadian industry or government departments. This process is also beginning to occur with the 1981 group. A summary of the current situation with respect to the employment of each of the five groups of Fellows is presented in Table I.14. It may be seen that, as of the date this Table was compiled, a total of 76 Fellows have found permanent positions in Canada, 68 of these being in universities. It is anticipated that, by June 30, 1985, an additional 15 of the 1980 group of Fellows will have obtained tenure-track positions in Canadian universities.

TABLE I.14

Employment Status of University Research Fellows

		1980	1981	1982	1983	1984	Total
Initial number of fellows		94	66	50	54	52	316
Resigned	a	2	1	0	0	0	3
	b	3	5	0	0	0	8
	c	3	2	0	0	0	5
	d	4	3	1	0	0	8
	e	9	8	2	1	0	20
Current fellows	f	42	6	0	0	0	48
	g	31	41	47	53	52	224

Notes:

a	resigned fellowship for unknown reasons
b	fellowship terminated by NSERC
c	resigned fellowship to accept employment abroad
d	resigned fellowship to accept non-university position in Canada
e	resigned fellowship to accept tenure-track position in Canada
f	second term appointment with tenure-track position in Canada
g	on first term appointment

Table I.15 gives figures to show how the integration of the 1980 group of Fellows into permanent positions in Canada varies according to the discipline of the Fellows. Although these figures are subject to change, it appears that the disciplines in which integration is least successful are Physics/Astronomy, and Psychology.

TABLE I.15

Employment of 1980 Fellows in Permanent Positions in Canada, by Discipline

	University	Non-University	Not yet in Permanent Positions
Biological Sciences	13	0	9
Chemistry	8	1	3
Computer Science	1	0	0
Earth Sciences	0	0	2
Engineering	8	2	4
Management Science	1	0	0
Math/Statistics	10	0	2
Physics/Astronomy	7	1	6
Psychology	3	0	5
Totals	51	4	31

Note: These figures are as of March 4, 1985 and are subject to change.

A-7.3 Evaluation of Program

This program has not yet been evaluated by external consultants. It is, however, being carefully monitored by NSERC's Research Manpower Committee.

A-8 Industrial Research Fellowships

A-8.1 Program Objectives and Description

The program of industrial research fellowships provides doctoral graduates in the natural sciences or engineering an opportunity to gain industrial research and development experience for periods of up to three years. This program has the following objectives:

a) to encourage highly qualified scientists and engineers to seek careers with industrial organizations in Canada;

b) to promote the transfer of technology from the universities to industry;

c) to assist Canadian companies, particularly the smaller ones, to develop an improved capability in research, development and/or innovation;

d) to provide an opportunity for potential university faculty members to gain meaningful research and development experience in an industrial environment.

Candidates for these awards are selected by industrial organizations and nominated by them for consideration by the selection committee. Nominees must be Canadian citizens or permanent residents of Canada. They must hold, or expect to hold a doctoral degree by the proposed date of appointment. Industrial research fellowships are intended primarily for new doctoral graduates seeking employment in industry for the first time. Preference is given to nominees who have had not more than five years of experience following receipt of their doctoral degree.

Successful nominees are given three year appointments and are employees of the company which nominated them. Their activities are governed by company policies in the same manner as are regular employees. During this three year period NSERC provides to the company a contribution of $25,900 per year towards the cost of the Fellow's salary and fringe benefits. The company is expected to pay the Fellow a salary which is comparable to that offered to other employees having similar qualifications, experience and responsibilities. Fellows are expected to be engaged in research, development and/or innovation-related activities, including research project management.

This program replaced a rather similar program of Industrial Postdoctoral Fellowships in 1980. Holders of the latter awards were permitted to convert their fellowships to Industrial Research Fellowships.

A-8.2 Experience During Past Five Years

Since the introduction of the Program in late 1980, a total of 122 companies located in all provinces and in the Northwest Territories have received Fellows. The numbers of nominations, fellowships offered and fellowships declined to date are given in Table I.16. The figures for 1984-85 are not final and are subject to minor changes. An analysis of the fellowships held by discipline is given in Table I.17. It is seen that the four biggest discipline groups participating in this program have been:

Chemistry	35% of all awards
Engineering	25% " " "
Biological Sciences	18% " " "
Physics	13% " " "

TABLE I.16

Number of IRFs Offered and Declined and Number of IPDF Conversions

Year	No. of Nominations	No. Awards Offered	No. Awards Declined	No. IPDF Conversions	No. New IRFs
1980-81	63	30	3	17	10
1981-82	128	63	7	9	47
1982-83	61	41	2	5	34
1983-84	65	39	4	0	35
1984-85	105	58	3	0	55
Totals	422	231	19	31	181

TABLE I.17

Number of IRFs Held by Discipline and Year

Discipline	1980-81	1981-82	1982-83	1983-84	1984-85	Totals
Biological Sci.	5	10	7	11	5	38
Chemistry	11	21	12	8	23	75
Computer Sci.	0	0	0	0	1	1
Earth Sci.	0	1	0	1	1	3
Engineering	4	16	11	6	15	52
Management Sci.	0	0	0	0	0	0
Math/Stats	0	0	1	0	1	2
Physics	5	6	4	8	5	28
Psychology	1	1	4	1	4	11
Other	1	1	0	0	0	2
Totals	27	56	39	35	55	212

The distribution of companies receiving Fellows by province is given in Table I.18. It is seen that the majority of these organizations are located in Ontario. The distribution of companies according to the number of Fellows received is shown in Table I.19. Those companies receiving 3 or more Fellows have, between them, received 84 (or 40%) of the 212 Fellows appointed so far.

TABLE I.18

Number of Organizations Receiving IRFs, by Province

Newfoundland	1
Prince Edward Island	1
Nova Scotia	2
New Brunswick	2
Québec	21
Ontario	73
Manitoba	1
Saskatchewan	1
Alberta	6
British Columbia	13
Northwest Territories	1
	122

It is NSERC's hope that many of the Fellows will receive regular appointments with their host companies following the conclusion of their awards, and that others will enter research-oriented employment in other companies or with the universities. To date, only 53 of the 212 Fellows

TABLE I.19

Distribution of Companies According to Number of IRFs Received

Number of IRFs Received	Number of Companies
1	79
2	24
3	8
4	3
5	4
6	2
7	1
9	1

have terminated their awards. Table I.20 indicates the employment sector for these 53 former Fellows. It is seen that 35 (or 66%) of this group of Fellows is known to have been integrated into regular positions in Canada.

TABLE I.20

Employment of IRFs Terminating Awards

Award Year	Awards Held	No. Terminated	Employment Sector					
			Same Co.	Canadian Univ.	Other Can. Employer	Abroad	Other	Unknown
1980-81	27	14	6	1	0	2	2	3
1981-82	56	28	10	4	8	3	1	2
1982-83	39	10	3	0	3	2	1	1
1983-84	35	1	0	0	0	0	0	1
1984-85	55	0	0	0	0	0	0	0
Total	212	53	19	5	11	7	4	7

A-8.3 Evaluation of Program

An evaluation of the Industrial Research Fellowships program has been undertaken by external consultants. Among the conclusions reached by the consultants, based upon a sample of 84 current or recently terminated Fellows, are the following:

(a) 85% of current IRFs agreed that their fellowship is providing them with an opportunity to gain valuable research skills;

(b) 68% reported that their expectations with respect to career development and research experience have been either completely or mostly fulfilled by the IRF program;

(c) 76% agreed that their fellowship is providing them with time to explore and generate potential career opportunities;

(d) 44% agreed that without their fellowship there was a good chance that they would not have found a job in research and development;

(e) 45% of the current IRFs who stayed in Canada for their fellowship were not certain that they would have remained in Canada without the award; and

(f) 81% of current IRFs plan to stay in Canada after completing their fellowship term.

SECTION B - SUMMARY OF "RESEARCH TALENT IN THE NATURAL SCIENCES AND ENGINEERING"

(Supply and Demand Projections to 1990)

B-1 Purpose

This paper presents "conditional" forecasts of the research talent required for the government's economic growth and research and development investment targets. A number of alternative scenarios are also assessed. The study limits itself to postgraduate manpower in the natural sciences and engineering.

B-2 Assessment of earlier GERD and highly qualified manpower (HQM)targets

NSERC's first Five-Year Plan incorporated manpower programs based on the government's 1.5% Gross Expenditures on Research and Development (GERD) target for 1983, later extended to 1985. Analysis of the manpower requirements suggested that there would not be adequate supplies of research trained personnel to achieve this target.

The 1985 GERD target will, in fact, not be achieved. According to the most recent GERD data, in constant dollar terms, GERD increased by only half its planned rate. The biggest shortfall occurred in industrial R&D growth, which advanced by only one-third of the target rate, both in funding and performance. The federal government almost achieved its target growth rate for **funding** R&D, and research **performed** directly by the federal government far exceeded the target rate. Consequently, its relative importance as a performer of R&D has increased rather than decreased.

Compared to the original target, research manpower has grown by less than half the projected rate. The actual **net** increase over the projection period amounted to close to 8,000 researchers, or about one-half the number projected in the first Five-Year Plan. This is consistent with the degree to which the GERD target was realized. During this period, NSERC's manpower programs were largely responsible for the availability of new researchers, and were instrumental in improving their qualifications.

B-3 GNP and GERD assumptions to 1990

The second Five-Year Plan of the Council, rather than reacting to a single, narrowly-defined target, tries to get a more complete perspective of highly qualified manpower requirements by examining a wide range of plausible scenarios from now to 1990. The scenarios should be seen neither as forecasts or policy options. Their main purpose is to help identify any potential manpower bottlenecks in a more comprehensive and more systematic way than would be possible with a single target. The study examines the growth rate of GNP, the target GERD/GNP ratio for 1990, the distribution of R&D among the various sectors, the rate of attrition research workforce, and the amount of R&D expenditures per researcher. The assumptions themselves are selected to "bracket" past experience, possible future trends, and policy targets.

B-3.1 The Growth of GNP

The volume of GNP, according to the November, 1984 Economic Statement of the Minister of Finance, is projected to grow by 2.4% in 1985, and 3.4% per year thereafter until 1990. This averages to 3.2% per year for the 1984-90 period. Additional simulations are carried out on the basis 0%, 1.1%, 2.2% and 3.7% growth of real GNP.

B-3.2 GERD/GNP Ratio

The GERD/GNP ratio assumptions range from an unchanged 1984 ratio of 1.24%, to 1.50% which corresponds to an approximate doubling of today's GERD in current dollars, to 2% which corresponds to an approximate doubling of today's GERD in constant dollars, and to 2.5%, which represents a doubling of today's GERD/GNP ratio. The GERD ratio assumptions are for 1990, which is the time frame for the Council's new Five-Year Plan.

B-3.3 GERD Distribution by Funder and Performer

Assumptions are also made about possible changes in the proportion of R&D performed (and funded) by the various R&D sectors, namely the federal government, the provincial governments (including the Provincial Research Organizations), industry, universities, and the "other" sector (mainly non-profit institutions). Simulation results are based on the following three performer/funder scenarios:

(a) The 1984 GERD distribution. The GERD distribution will not change between now and 1990.

(b) The ADJUSTED distribution. The GERD distribution will adjust in a number of ways:

- the growth rate for federal intramural expenditures will be somewhat lower than that for total GERD, implying a reduction of its share in GERD from the present 25.1% to 21% in 1990;

- the federal and the provincial governments' assistance for R&D performed by industry and the universities will rise at the same rate as total GERD;

- industry will have the highest growth rate of any of the sectors for R&D performed and funded;

- industry will increase its contributions to university R&D significantly, as cooperation between the two sectors becomes more intensive;

- R&D performed at the universities will retain its current 20% share in GERD. The share was 24.3% in 1979. Any further decline in the share would weaken the capacity of the universities to provide highly qualified manpower training and to develop new knowledge and skills;

- while university R&D sponsored by external funders will have to rise, the universities themselves will also be required to generate more R&D support than in recent years. Their ability to do so will be conditional on the type of agreement reached between the federal and provincial governments on R&D cost-sharing in the context of the Established Programs Financing negotiations.

(c) The RESTRUCTURED distribution. The third configuration is similar to (b), except that industry will have an even larger, and government an even smaller role.

B-4 Highly Qualified Manpower (HQM) Demand Projections

B-4.1 The 1984 Stock of Researchers

As of 1984 the total research manpower resources amounted to some 28,340 person years. The aggregate estimate of researchers includes personnel at all three levels of qualification, that is B.Sc., M.Sc., and Ph.D.; their approximate proportions are derived on the basis of a number of survey results over the years. From 1975 to 1984, the total number increased by 10,140, with most growth taking place in industry. That sector accounted for 77%, the federal government for 10%, and the provinces and the universities each for 5% of the increase.

B-4.2 Demand Elements

The HQM demand estimates to 1990 include the following elements: (1) The net growth of the stock of researchers from 1984 to 1990, implied by the various scenarios. This is the largest demand element, and it varies according to the GNP, GERD scenario, and productivity assumptions. (2) The replacement needs for researchers who leave research, and who retire or die; this is the second largest demand element, and is a function of the 1984 stock. (3) The demand for researchers arising from R&D related activities (e.g., where there are joint activities such as research and teaching, research and administration, etc.). And (4) demand due to the normal labour force attrition of postgraduates with degrees in the Natural Sciences and Engineering who work in non-R&D occupations.

(a) Net Growth of the Stock of Researchers

The net growth to 1990 of the total number of researchers in each sector is a function of the aforementioned growth in real GNP, change in the GERD/GNP ratio (i.e., the GERD target), changes in the distribution of GERD by performing sector, and changes in the GERD/researcher ratio.

Changes in the effective amount of expenditures per R&D professional (i.e., in the GERD/researcher ratio) are also used in the model simulations. The GERD/researcher ratio varies from one sector to the next, but has been fairly constant within each sector since at least 1975. A number of model simulations have been based on assumed increases in this ratio between 1984 and 1990 that might result from more sophisticated equipment and technical staff, even though such increases do not appear to be consistent with the actual experience since 1975.

(b) Replacements

The traditional length of the active R&D career of the average researcher has been about 15 years. If this pattern continues, more than one-third of the 1984 stock of researchers will have to be replaced by 1990. A longer R&D career for the average researcher would reduce the need for new people. Simulations of supply-demand are, therefore, also based on a number of longer career assumptions.

When it comes to replacement, the universities are now in a different, more difficult situation. Given the serious constraints on new staffing, the replacement assumption has been set at 500, a much lower rate than for the other sectors and, perhaps, too low.

(c) R&D Related Demand

Most researchers do other things besides R&D. In estimating the number of full-time equivalent university researchers, Statistics Canada applies the generally accepted split that professors in the Natural Sciences and Engineering spend about one-third of their time on R&D, and two-thirds on teaching and other related activities. The proportion of time that researchers in the other sectors spend on related activities is probably much smaller, but information on this aspect is not yet available. This study accepts that the need for new full-time equivalent researchers implies a requirement for some additional personnel. It is assumed that, at the Master's level, 20 additional persons will be required for every 100 identified full-time equivalent R&D positions. At the Ph.D. level, no additional requirements are assumed, implying that new staff will be engaged basically in R&D. This probably results in an understatement of total requirements.

(d) Other HQM Demand

The other source of HQM demand is the non-R&D labour force. According to the most recent survey by Statistics Canada (held in August, 1982), there were 62,000 M.Sc.s and 32,000 Ph.D.s with degrees in Natural Sciences and Engineering fields in the labour force, and it is estimated that only about one-fifth of these degree holders work in R&D. The mortality rate for persons in the labour force has been applied to the remaining 75,000, yielding an annual replacement requirement of 1,250. As Ph.D.s would be in even greater demand for R&D jobs than M.Sc.s, the non-R&D replacements are assumed to be mostly Masters (1,000 Masters vs 250 Ph.D.s). At best, this is a minimum estimate that barely allows for replacements due to the death rate.

B-4.3 Degree and Discipline Breakdown

The final step in the demand estimate is to break down the growth, replacement and related requirements by degree and discipline to relate them directly to the supply estimates. This is done for each of the R&D sectors, because each employs a research force with different degree and discipline qualifications.

B-4.4 Demand Projections

The number of required M.Sc.s ranges from 1,285 to 3,772 per year under the two extreme sets of assumptions. The low number is generated by assumptions of zero growth in real GNP, no change in the GERD/GNP ratio, an unchanged 1984 GERD performer distribution by sector (i.e., high government and low industry shares), and a quite low replacement rate, based on an R&D career life assumption for the average researcher in the labour force of 25 years (significantly in excess of actual experience).

The high number is generated by a situation in which GNP grows by 3.7% per year (real), the GERD/GNP ratio rises to 2.5%, there is a radical restructuring of GERD away from government and into the private sector, and a replacement rate for researchers based on the traditional length of R&D career life of about 15 years.

The comparable numbers of Ph.D.s using the two sets of assumptions range from 556 to 3191.

B-5 Supply of Highly Qualified Manpower (HQM)

B-5.1 Recent Postgraduate Growth

Since the beginning of the Council's first Five-Year Plan, there has been a resurgence of interest in postgraduate studies at Canadian universities. In 1983-84, there were 16,345 full-time students enrolled in the Natural Sciences and Engineering (including Health) at Canadian universities, up from 11,216 in 1978-79. Fully one-third of the increase, however, was due to an inflow of foreign (temporary visa) students who, at the end of their studies, must leave Canada. The following table shows the incidence of foreign student growth at the two degree levels:

Growth in Natural Sciences and Engineering (NSE) Postgraduate Enrolments, 1979 to 1984

(Number of Students)

	Total	Canadian	Foreign
M.Sc.s	3,659	2,691	968
Ph.D.s	1,470	729	741
All Levels	5,129	3,420	1,709

As is evident from this table, the growth of temporary visa enrolments was much stronger at the Ph.D. than at the M.Sc. level -- visa students accounted for over 50% of the increase in Ph.D. enrolments, and 26% of M.Sc. enrolments. In the Applied Sciences and Engineering, a discipline of particular importance to Canadian industry, foreign students made up almost the entire **increase** (85%) at the Ph.D. level.

B-5.2 Forecast of Enrolments and Degrees

The forecast of postgraduate enrolments and degrees is based on trends in undergraduate enrolments and continued strong interest in part-time postgraduate studies. The growth of the undergraduate student population in the Natural Sciences and Engineering fields peaked in 1982-83, closely following the pattern of the underlying source population. From 1984 to 1990, growth is projected to level off. M.Sc. enrolments, excluding foreign students, are assumed to follow a roughly similar path, with a time lag. In the past, there has been a fairly high and stable correlation between NSE undergraduate enrolments in one year and M.Sc. enrolments one year later.

M.Sc. enrolments to 1990 based on Canadians and Permanent Residents is forecast to grow more rapidly than that of foreigners. In particular, visa students at this level are assumed to decline from 2,490 in 1984 to 2,000 in 1990. Total Canadian full-time M.Sc. enrolments in NSE are forecast to rise from 8,371 in 1984 to 10,523 in 1990 at an average annual growth rate of 3.9%.

The forecast of M.Sc. degrees granted is based on the observed relationship with enrolments in earlier years. There is a strong and stable correlation between enrolments one year and degrees granted two years later. According to the data, 4 M.Sc. degrees have been granted in one year for every 10 full-time students enrolled two years earlier during the years since 1970. As degrees are earned by part-time as well as full-time students, this correlation implies that the proportion of part-time to full-time degree earners has been fairly constant in the past. It is assumed to continue during the forecast period. Total M.Sc. degrees granted to Canadian and Permanent residents are forecast to increase from 2,502 in 1984 to 3,900 in 1990.

Ph.D. enrolments are forecast to grow at a fairly rapid rate initially, reflecting the recent increases in M.Sc. level enrolments, particularly in Engineering. After growing by 7.5% per year, the growth rate is forecast to decline steadily during the years to 1990. The number of visa students during the next two years is expected to remain at the 1984-85 level of 1,870, and then to stabilize at around 1,500. Ph.D. enrolments of Canadians and Permanent Residents are expected to rise from 3,616 in 1984 to 4,700 in 1990.

Ph.D. degrees granted to Canadians and Permanent Residents are forecast to increase from 670 in 1984 to 994 in 1990. This forecast is based on the correlation between enrolments in one year and degrees granted subsequently. The data indicate that, since 1970, some 22 Ph.D. degrees were granted in one year for every 100 full-time students enrolled three years earlier. The stability of this relationship indicates that the ratio of full-time to part-time students who obtained Ph.D.s was constant during this period. It is assumed that this relationship will continue to 1990.

B-5.3 Total Annual Supply

The postgraduate degrees earned by Canadians and Permanent Residents form the basis for estimating the supply of new researchers that will be available from domestic sources. (The role of immigration is discussed below.) As far as M.Sc.s are concerned, it is estimated that some 44% of new graduates will stay in the postgraduate program to study for a doctorate, and will not be available immediately for the labour market. (A postdoctoral fellowship is considered to be employment for the purposes of this analysis.) The cumulative 6-year total of postgraduate degrees that will be awarded to Canadians is forecast to amount to 26,000. A little over 5,000 of these will be Doctorates and the remainder, almost 21,000, M.Sc.s. However, as some of the M.Sc. graduates remain in postgraduate studies, less than three-fifths will actually be available to the labour market. Based on this, the average annual supply of postgraduates in all fields of NSE for the years 1984-90 is 1,952 M.Sc.s and 842 Ph.D.s. These estimates are further broken down by field of study, based on longer-term trends in the enrolment and degree shares of the various fields within total NSE.

B-6 The Gap Between Supply and Demand

The simulation results indicate that there would be overall shortages in virtually all scenarios. Table 1 summarizes the model simulations for 105 combinations of assumptions covering almost every plausible future development for the projection period. Only under conditions of very little or no economic growth, and no further increase in the GERD investment target, would the forecast supply be sufficient to meet demand. The shortages would be relatively more serious for Ph.D.s than for M.Sc.s.

The calculations show that the supply-demand gap could be reduced by increasing the "productivity" of researchers. Depending on the level of GNP and GERD, for every 1% increase in the amount of real R&D

per researcher, there would be a 60-120 reduction in HQM requirements. The table provides results for one set of scenarios with a 25% increase in the level of R&D per researcher over the period to 1990 in all sectors except the universities, and with a 50% increase in the universities. While this assumption is unrealistically optimistic in the light of actual experience, it demonstrates that even with such an assumption, significant shortages would still remain.

The imbalances would be more serious in every scenario for certain components of the labour market, such as Applied Scientists and Engineers, new researchers with Ph.D. qualifications, and research talent in specific high demand areas such as Computer Science and Biotechnology.

B-7 Closing the Gap

There is relatively little scope for increasing the supply of postgraduates over a timespan as short as the projection period to 1990. The students who will graduate between now and 1990 either are in postgraduate courses already, or are about to enter from undergraduate studies.

The calculations indicate that the requirements for new postgraduates could be reduced, to a certain extent, by increasing the "productivity" of researchers through such means as improved infrastructure and equipment, more technical support, and by creating career conditions under which researchers would remain in R&D for a longer period. However, while highly desirable in the interest of optimizing scarce resources, neither productivity growth nor a longer R&D career has been the traditional experience during the past decade.

Occupational mobility is not a ready source of supply. There is no surplus of recent postgraduates who could readily move into R&D positions, although there are a few exceptions where retraining could be a possibility. Postgraduates of earlier years who are currently employed in non-R&D jobs would not qualify for new research functions requiring state-of-the-art knowledge.

Nor will we be able to rely on immigration. In the high growth disciplines, shortages are world wide. Furthermore, unless there is an improvement in the outlook for R&D jobs in Canada, we run the real risk of losing the already limited talent being trained here to other countries.

The support of research training is an essential "up-front" investment. The lead times for training are so long, and the requirements for any increased science and technology effort so large, that this investment must begin immediately. This is a long-term process requiring a long-term commitment.

For the immediate future, NSERC is proposing further increases in its Undergraduate Summer Research Awards program designed to attract more students to research training. Regarding support of postgraduates, the Council has proposed increases to the Postgraduate Scholarship Program and the Operating Grants Program which would result in support for almost 50% of full-time Canadian students in the fields that are within the Council's mandate by 1990.

The poor financial situation of the universities and the age structure of the existing faculty, make it increasingly difficult for the universities to respond quickly enough to the emerging requirements. To address these structural problems, the Council is strengthening its University Research Fellowship and Industrial Research Professorship program and is proposing a new NSERC Research Professorship program, as well as more support for equipment and infrastructure.

All Council programs are instrumental in training new research talent, because all students, with or without scholarships, benefit from the higher quality scientific environment fostered through NSERC programs.

While the Council's programs are pivotal, they cannot by themselves generate all the new research talent that will be required. New imaginative and nonconventional forms of research training will have to be developed, preferably in cooperation with employers.

In the longer run, a commitment by industry to long-term research, and a restructuring of the reward system in favour of research trained manpower, would have powerful influences on the attitudes of all students towards an R&D career and would, eventually, assure an adequate supply of research manpower.

Table 1

SUMMARY OF SUPPLY-DEMAND DIFFERENCES, BASED ON VARIOUS MODEL SIMULATIONS
TOTAL FOR ALL NSE DISIPLINES

ANNUAL SUPPLY-DEMAND DIFFERENCES TO 1990 (SHORTAGES IN BRACKETS)
TOTAL FOR ALL NSE DISCIPLINES

GNP AND GERD ASSUMPTIONS			LENGTH OF R&D CAREER LIFE ASSUMPTIONS					
REAL GNP GROWTH 1984-90 %	1990 GERD/GNP RATIO %	1990 GERD PERFORMER/FUNDER DISTRIBUTION	15 YEARS	15 YEARS	20 YEARS	20 YEARS	25 YEARS	25 YEARS
			MScs	PhDs	MScs	PhDs	MScs	PhDs
			(NUMBER)	(NUMBER)	(NUMBER)	(NUMBER)	(NUMBER)	(NUMBER)
0	1.24	1984 DISTRIBUTION	453	119	595	231	667	286
0	1.50	1984 DISTRIBUTION	160	(262)	302	(150)	374	(95)
0	2.00	1984 DISTRIBUTION	(412)	(1,006)	(270)	(894)	(198)	(839)
0	2.00	ADJUSTED DIST.	(434)	(931)	(292)	(819)	(220)	(764)
0	2.00	RESTRUCTURED DIST.	(490)	(795)	(348)	(683)	(276)	(628)
0	2.00	RESTRUCTURED, PROD.	(16)	(85)	126	27	198	82
0	2.50	RESTRUCTURED DIST.	(1,082)	(1,487)	(940)	(1,375)	(868)	(1,320)
1.1	1.24	1984 DISTRIBUTION	361	(1)	503	111	575	166
1.1	1.50	1984 DISTRIBUTION	44	(414)	186	(302)	258	(247)
1.1	2.00	1984 DISTRIBUTION	(568)	(1,208)	(426)	(1,096)	(354)	(1,041)
1.1	2.00	ADJUSTED DIST.	(590)	(1,127)	(448)	(1,015)	(376)	(960)
1.1	2.00	RESTRUCTURED DIST.	(650)	(983)	(508)	(871)	(436)	(816)
1.1	2.00	RESTRUCTURED, PROD.	(145)	(224)	(3)	(112)	69	(57)
1.1	2.50	RESTRUCTURED DIST.	(1,283)	(1,721)	(1,141)	(1,609)	(1,069)	(1,554)
2.2	1.24	1984 DISTRIBUTION	260	(132)	402	(20)	474	35
2.2	1.50	1984 DISTRIBUTION	(79)	(573)	63	(461)	135	(406)
2.2	2.00	1984 DISTRIBUTION	(732)	(1,421)	(590)	(1,309)	(518)	(1,254)
2.2	2.00	ADJUSTED DIST.	(756)	(1,335)	(614)	(1,223)	(542)	(1,168)
2.2	2.00	RESTRUCTURED DIST.	(820)	(1,181)	(678)	(1,069)	(606)	(1,014)
2.2	2.00	RESTRUCTURED, PROD.	(281)	(372)	(139)	(260)	(67)	(205)
2.2	2.50	RESTRUCTURED DIST.	(1,495)	(1,969)	(1,353)	(1,857)	(1,281)	(1,802)
3.2	1.24	1984 DISTRIBUTION	158	(265)	300	(153)	372	(98)
3.2	1.50	1984 DISTRIBUTION	(203)	(734)	(61)	(622)	11	(567)
3.2	2.00	1984 DISTRIBUTION	(896)	(1,635)	(754)	(1,523)	(682)	(1,468)
3.2	2.00	ADJUSTED DIST.	(922)	(1,543)	(780)	(1,431)	(708)	(1,376)
3.2	2.00	RESTRUCTURED DIST.	(990)	(1,380)	(848)	(1,268)	(776)	(1,213)
3.2	2.00	RESTRUCTURED, PROD.	(417)	(519)	(275)	(407)	(203)	(352)
3.2	2.50	RESTRUCTURED DIST.	(1,707)	(2,217)	(1,565)	(2,105)	(1,493)	(2,050)
3.7	1.24	1984 DISTRIBUTION	104	(336)	246	(224)	318	(169)
3.7	1.50	1984 DISTRIBUTION	(250)	(795)	(108)	(683)	(36)	(628)
3.7	2.00	1984 DISTRIBUTION	(984)	(1,748)	(842)	(1,636)	(770)	(1,581)
3.7	2.00	ADJUSTED DIST.	(1,010)	(1,654)	(868)	(1,542)	(796)	(1,487)
3.7	2.00	RESTRUCTURED DIST.	(1,081)	(1,486)	(939)	(1,374)	(867)	(1,319)
3.7	2.00	RESTRUCTURED, PROD.	(489)	(598)	(347)	(486)	(275)	(431)
3.7	2.50	RESTRUCTURED DIST.	(1,820)	(2,349)	(1,678)	(2,237)	(1,606)	(2,182)

SECTION C - PROPOSAL FOR A PROGRAM OF NSERC RESEARCH PROFESSORSHIPS AT CANADIAN UNIVERSITIES

The Natural Sciences and Engineering Research Council of Canada (NSERC) is proposing a program of Research Professorships to reinforce research and development in Canadian universities.

C-1 The Problem

Important new opportunities are being presented to Canadian universities for research in areas of major social and economic significance for the nation. To respond effectively, it is essential to establish and develop research groups of sufficient size and stature to be able to compete with the best in any other country. Universities, however, because of severe budgetary restrictions, are unable to make the new appointments necessary to meet their growing teaching obligations, let alone to develop major strength in new areas of opportunity. Although the expanded manpower programs of NSERC have greatly improved opportunities for graduate training and, through the University Research Fellowship scheme, for university appointments at the beginning Assistant Professor level, the Council has no program whereby it can assist universities to develop major research strengths by appointments at a more senior level. Yet, it is from this latter group that will come the leadership so essential for major scientific and technological breakthroughs.

C-2 The Proposal

The federal government, through NSERC, would fund Research Professorships in scientific and technological fields in which there exist special opportunities and need, and would initially provide infrastructure, equipment and operating support to ensure maximum productivity of the research group associated with the Research Professorship. In some cases, fields would be those which are especially ripe for major intellectual advances and the research supported would be largely basic in nature. In other cases, emphasis would be more on application and movement of new knowledge from the university laboratory to industry and other elements of society. In the latter instance, special efforts would have to be made to encourage collaboration with industry or government, as appropriate.

Wherever possible, efforts would be made to build on existing strength to achieve the critical size essential for a major scientific or technological research endeavour. On occasion, however, the program would be used to establish research groups in fields that have not yet been developed in Canadian universities but for which there is an important national need.

The Council recognizes that the universities themselves are in the best position to identify areas of opportunity for exploitation and development and would expect each university to provide justification for the areas in which Research Professorships are proposed. Therefore, the Council would not solicit applications in specified fields. The following research areas are listed simply as examples of the types of activity the proposed program could embrace: biotechnology, materials science and engineering, surface science (including catalysis), artificial intelligence (including robotics), polymer science and polymer engineering, communications and forestry.

C-3 Regional Distribution

Although a major objective of the proposed program would be to obtain a greater concentration of strength in research areas of critical importance to Canada, this does not imply geographical concentration of research centres. Clearly, some research areas are more appropriate for certain regions of Canada than for others, e.g. ocean engineering on the East and West Coasts. In other fields, geographical considerations are less important and existing research strengths would be a determining factor. While a very high standard of quality would be required of all successful applications, efforts would be made to ensure a reasonable distribution by region.

C-4 Eligibility

The target population for appointment would be persons of international stature who are at or are approaching the most productive period of their careers and who would qualify for the rank of Professor or Associate Professor.

Since the primary purpose of the proposed program would be to assist universities to develop research groupings of critical size by the appointment of new faculty, Research Professors would normally be expected to be persons who are not members of the faculty of the applying university. When an existing faculty member is nominated for an NSERC Research Professorship, a plan must be presented for using the salary amount saved to strengthen the overall research effort in the designated area. This plan might be expected to include the appointment of one or more additional faculty, and would be considered by NSERC in the assessment of the overall proposal.

There would be no citizenship requirement for appointment of an NSERC Research Professor, but the employment validation procedure established by Employment and Immigration Canada would need to be followed for the recruitments of persons who are neither Canadian citizens or permanent residents of Canada. The program should be viewed as one further means of attracting to Canada outstanding Canadian researchers now working in other countries.

C-5 Term and Conditions of Appointment

The initial appointment for an NSERC Research Professor would be for a five-year term during which time NSERC would pay the salary and fringe benefits of the appointee. In the fourth year, a rigorous review would be carried out by a Site Visit Committee and a decision for renewal would be based both on the productivity of the incumbent and the quality and significance of the research output of the group of which he or she is a member.

If the review is favourable, the NSERC Research Professorship would be renewed for an additional five years during which time there would be a gradual phasing-out of salary support by NSERC and a phasing-in of support by the university. Should the review be unfavourable, NSERC support would be phased-out more rapidly, usually over two years. In no case would salary support extend beyond a total of ten years.

While NSERC appointees would carry the title of NSERC Research Professor or NSERC Research Associate Professor, as appropriate, and while NSERC would be paying salaries and fringe benefits in whole and in part, the appointees would be employees of their university and would have all of the rights and privileges pertaining to their position. Regular university procedures for the granting of tenure, promotion and the determination of annual salary increments would apply. The nature of the initial appointment, tenure stream or limited term, would be determined by the university.

Research Professors would be permitted to accept a light teaching load and to carry out some administrative duties, especially those associated with management of the research group. Research and graduate student supervision, however, would be expected to comprise their major responsibility.

C-6 Research Associates

Although the objective of the Program would be to establish and develop research groups of critical size through appointments at the Professor and Associate Professor level, in certain cases researchers at a more junior level might be required in addition to the senior appointees. Proposals, therefore, might include Research Associates who would normally be persons with one or more years of research experience beyond the doctorate and who might qualify for the rank of Assistant Professor. In addition, universities would be expected to use the existing University Research Fellowship or Attachés de recherche du CRSNG program for appointments at this level. Research Associates, provided they are given academic privileges by their university, would be eligible for NSERC research grants.

C-7 Infrastructure Support

Where applicable, an initial award would include infrastructure support for up to three years. Such support would encompass the activities of the entire research group with which the NSERC Research Professor is associated. Thereafter, applications would be submitted through the regular Infrastructure Grants program. Research resources eligible for infrastructure support would be those set out in the current edition of the Awards Guide.

C-8 Equipment

Funds for specific items of equipment which are essential to the work of the Research Professor and the research group of which he or she is a member would be included in the first year of an award. Thereafter, applications would be made through the regular equipment programs of the Council.

C-9 Operating Grants

Operating grant support for up to three years would be included in the initial award for newly appointed Research Professors who were not currently recipients of such an award. Thereafter, Research Professors would apply through the regular Operating Grants program.

Research Professors who hold an NSERC Operating Grant at the time of appointment would be permitted to apply for supplementary funding based on the greater amount of time they would be devoting to research.

C-10 Application Procedures

Application procedures would take into account that frequently universities would not have identified candidates for Research Professorship positions at the time of application for funding under the program. They would find it difficult to proceed very far with recruitment without some clear indication that the proposal is likely to be approved. NSERC, on the other hand, could not be expected to give final approval until it is satisfied that the quality of persons being recruited meets the standards of excellence of the program. Therefore, successful applications would be expected to proceed through the following stages:

1) submission by the university of a letter of intent;

2) discussions with NSERC staff leading to the development of a detailed proposal which would include a statement on the nature of the research opportunity presented; a description of existing strengths at the university and of the way in which the appointment of one or more NSERC Research Professors would enhance these strengths; a description of special equipment and infrastructure requirements; an outline of university support, etc.;

3) review by a Site Visit Committee;

4) approval in principal of the proposal by NSERC with an indication of the approximate level of funding;

5) completion of the recruitment of the Research Professor(s) by the university, subject to NSERC approval;

6) negotiation between the university and NSERC staff on a detailed budget and other relevant matters;

7) development of a written agreement setting out the level of funding and schedule of payments by NSERC, the university support, including contributions to salaries where applicable reporting schedule, etc.

C-11 Scope and Costs

Proposals would be expected to range from an award of a single Professorship, with an associated operating grant, to fill a gap in the research strength of an existing group to a major proposal involving more than one Professorship, Research Associates and substantial equipment, infrastructure and operating grant support.

The following examples at three different levels of Year 1 funding serve to illustrate the range of proposals that would be supported under the program:

1) Single senior Research Professor

- salary and benefits	$ 80,000
- full operating grant support	$120,000
Total	$200,000

2) Medium sized research group

- salary and benefits for two Professorships, one at a full and one at an Associate Professor level	$ 130,000
- operating grant support	$ 120,000
- infrastructure support	$ 250,000
- equipment	$ 500,000
Total	$1,000,000

3) Major research group

- salaries and benefits for four Professorships, two at a full and two at an Associate Professor level	$ 250,000
- salaries and benefits for three Research Associates	$ 105,000
- operating grant support	$ 345,000
- infrastructure support	$ 600,000
- equipment	$1,500,000
Total	$2,800,000

The amounts charged to the program would be reduced in the second and subsequent years as equipment, operating grants, infrastructure grants and eventually salaries are phased-out or transferred to other NSERC programs which would require suitable augmentation in funding. Joint funding with industry would be explored for proposals in certain research areas.

The scope and costs of the program would depend on the availability of funds, the number, quality and size of proposals and the program's success in meeting its objectives. Assuming that in each of the first five years of the program, ten new proposals at the level of Example I, four at the level of Example II and one at the level of Example III were to be funded, the approximate costs would be as follows:

$Million 1984

Year 1	Year 2	Year 3	Year 4	Year 5
8.8	14.1	19.4	24.7	30.0

On this basis, by the end of the fifth year of the program, 110 Research Professorships and 15 Research Associateships would be held.

Following the end of Year 5, the program would be continued at the same level, increased or permitted to be phased-down depending on circumstances.

C-12 Summary

The program would:

(a) provide the means whereby universities could respond to opportunities for research in critical areas by establishing research groups of sufficient quality and size to ensure a major impact;

(b) help universities across Canada to improve the calibre of undergraduate and graduate programs in identified priority areas by facilitating hiring of additional faculty in these areas;

(c) offer the means of attracting to Canada some outstanding Canadian Researchers now working in other countries and also for encouraging the entry of industrial scientists and engineers into academia;

(d) do all of this through programs of NSERC which have a high degree of provincial acceptance.

APPENDIX II

RESEARCH INFRASTRUCTURE

INTRODUCTION

The term research infrastructure is used to describe NSERC support for the acquisition, maintenance and operation of facilities and other major resources which are necessary for the pursuit of research programs in science and engineering. These are supported through the programs of Equipment, Major Equipment, Major Installation, and Infrastructure grants. Table 1 provides an overview of expenditures for research infrastructure over the period 1979-80 to 1984-85.

TABLE 1

Expenditures for Research Infrastructure
(thousands of current dollars)

	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Equipment	4,894	12,916	17,319	17,825	16,459	15,018
Major Equipment	1,651	7,059	10,619	9,751	9,105	2,894
Major Installation	1,173	1,228	4,978	9,623	10,033	2,409
Subtotal - Capital Equipment	7,718	21,203	32,916	37,199	35,597	20,321
Infrastructure (and previous core/special core grants)	4,798	5,516	6,189	7,952	10,223	12,728
Total Research Infrastructure	12,516	26,719	39,105	45,151	45,820	33,049

*Data do not include strategic equipment grants.

A. EQUIPMENT SUPPORT

A.1 Program Objectives

The objectives of Equipment, Major Equipment and Major Installation grants are to foster and enhance the research capability of university researchers and to provide a stimulating environment for research training by supporting the purchase of research equipment.

A.2 Program Characteristics and Overview

Applications for equipment are considered in one of three categories according to the total amount requested. In the 1984-85 competition these categories were:

- Equipment grants: from $7,001 to $125,000
- Major Equipment grants: from $125,001 to $275,000
- Major Installation grants: more than $275,000.

Applications for equipment are divided into these three categories because of the need for increasingly intensive review procedures as the amount of the request increases; this arises partly from the fact that major facilities are often used by many researchers from locations outside the host institution.

The 1981 report of the Task Force on Research Equipment emphasized the importance of, and the need for, a modern equipment base in Canadian university laboratories. The arguments employed are still valid today - the necessity for efficient and productive research and for effective research training, especially in disciplines where state-of-the-art technology is advancing rapidly. Since 1980 there has been a dramatic increase in the demand for new research equipment, a pressure to which NSERC has been able to respond at least in part. Table 2 provides an overview of the requests and awards by equipment category for the 1980 to 1984 competitions.

An after-the-fact review of the regional distribution of research equipment expenditures from 1979-80 to 1984-85 reveals that researchers in all parts of Canada have benefitted from research equipment awards in amounts which are more or less comparable to the percentage of operating grant recipients (on a 1983-84 base). Table 3 provides an overview of the total support awarded to each region in each of the equipment categories with a comparison to the percentage of operating grant recipients. It should be stressed, however, that regional distribution is not a criterion in the selection process.

A.3 Discipline Distribution of Equipment Support

Because of the multi-disciplinary user community for Major Installations, only Equipment and Major Equipment categories have been analyzed

TABLE 2

Research Equipment Grants[1]
1980-81 to 1984-85 Competition Years

	1980-81	1981-82	1982-83	1983-84	1984-85
a) REQUESTS (current $000)					
Equipment	17,508	32,559	33,393	35,101	44,050
Major Equipment	7,588	19,227	14,481	16,788	23,378
Major Installation	2,230	12,744	10,979	20,356	14,027
TOTAL	27,326	64,530	58,853	72,245	81,455
b) AWARDS (current $000)					
Equipment	6,447	14,348	13,255	14,149	16,650
Major Equipment	3,864	10,074	5,968	7,533	9,098
Major Installation	659	6,117	4,994	7,373	7,016
TOTAL	10,970	30,539	24,217	29,055	32,764
c) FUNDING RATE (b/a)					
Equipment	0.37	0.44	0.40	0.40	0.38
Major Equipment	0.51	0.52	0.41	0.45	0.39
Major Installation	0.30	0.48	0.45	0.36	0.50
TOTAL	0.40	0.47	0.41	0.40	0.40
d) REQUESTS (No.)					
Equipment	586	994	918	976	1,100
Major Equipment	51	132	80	88	110
Major Installation	7	25	19	17	19
TOTAL	644	1,151	1,017	1,081	1,229
e) AWARDS (No.)					
Equipment	281	522	433	447	496
Major Equipment	27	79	33	43	42
Major Installation	3	14	14	10	10
TOTAL	311	615	480	500	548
f) SUCCESS RATE (e/d)					
Equipment	0.48	0.53	0.47	0.46	0.45
Major Equipment	0.53	0.60	0.41	0.49	0.38
Major Installation	0.43	0.56	0.74	0.59	0.53
TOTAL	0.48	0.53	0.47	0.46	0.45

[1] The total value of each award was included in the year of the request.

TABLE 3

Regional Distribution of Research Equipment Expenditures (thousands of current dollars) from 1979-80 to 1984-85

Region	Equipment	Major Equipment	Major Installation	Total	% Total	% Operating Grant Recipients[1]
Atlantic	5,751	2,640	1,691	10,082	7	9
Quebec						
- French	9,781	3,925	5,817	19,523	14	13
- English	5,705	2,595	905	9,205	7	8
Ontario	29,998	15,876	8,967	54,841	40	42
Prairies	10,605	8,495	7,293	26,393	20	18
B.C.	7,954	4,662	2,886	15,502	11	11
TOTAL	69,794	38,193	27,559	135,546		

[1] 1983-84

by discipline. Tables 4 and 5 provide details on the number and dollar value of Equipment requests and awards by discipline grouping over the period 1980-1981 to 1984-85 (by competition year). These data are not necessarily consistent with fiscal year data because awards emanating from any one competition have frequently been issued over two fiscal years. Tables 6 and 7 provide similar data for Major Equipment requests and awards. The amounts requested increased over this period in all disciplines but particularly so in Engineering, Chemistry, Biology and Computing and Information Science. The increasing sophistication of research equipment and reliance on state-of-the-art facilities for research have contributed to this sharp increase in demand.

A.4 Nature of Major Equipment and Major Installation Applications and Awards

In order to ascertain the rationale for Major Equipment and Major Installations a sample of applications was reviewed. Table 8 presents a profile of Major Equipment and Major Installation awards from 1980-1981 to 1984-85. Of particular interest are the following:

- about 40% of the requests for Major Equipment are for replacement of obsolete or unserviceable equipment; in the case of Major Installation this is the reason in 24% of the cases

- where obsolete or unserviceable equipment is being replaced, its age exceeds 10 years (about 13 years for Major Equipment; over 11 years for Major Installation)

- Canadian manufacturers are quoted as being able to provide 21-29% of the equipment required for Major Equipment, 31% for Major Installation

- the more expensive the facility, the more likely it is to serve as a regional centre.

Another analysis displayed in Table 9 provides information on the involvement of university and industry in Major Equipment and Major Installation awards over the period 1980-81 to 1984-85: 80 to 86% of Major Equipment awards involve only the university community; 75% of Major Installation awards are university-based only. The data in the second portion of Table 9 describe the number of universities, departments and other institutions which supported the original application because of their intent to exploit the facility. The number of users from industry, and to a lesser extent government or research institutes, tends to be underestimated because often only senior researchers are listed as potential users.

TABLE 4

Equipment Grants by Discipline for the 1980 to 1984 Competitions

	Requests (No.)						Awards (No.)					
	1980-81	1981-82	1982-83	1983-84	1984-85	% Total	1980-81	1981-82	1982-83	1983-84	1984-85	% Total
Biology	146	286	270	293	341	29	64	132	134	136	162	29
Psychology	15	39	41	55	52	4	7	24	23	26	24	5
Chemistry	110	164	146	143	157	16	41	78	63	54	67	14
Physics	78	133	117	97	103	12	42	88	56	45	47	13
Engineering	171	263	220	249	315	27	88	149	104	124	140	28
Earth Sci.	45	75	74	73	77	8	28	30	32	36	37	8
Comp./Info. Sci.	14	20	37	48	40	3	7	12	15	18	14	3
Math./Stats.	3	7	7	10	7	< 1	2	5	4	6	3	<1
Interdisc.	4	7	6	8	8	<1	2	4	2	2	2	<1
TOTAL	586	994	918	976	1,100	100	281	522	433	447	496	100

TABLE 5

Equipment Grants by Discipline for the 1980 to 1984 Competitions

	Requests (Current $000)						Awards (Current $000)					
	1980-81	1981-82	1982-83	1983-84	1984-85	% Total	1980-81	1981-82	1982-83	1983-84	1984-85	% Total
Biology	3,507	7,649	7,756	8,788	10,679	24	1,177	2,819	3,017	3,525	4,063	23
Psychology	414	948	932	1,171	1,092	3	127	343	290	449	407	2
Chemistry	3,446	5,900	5,922	5,775	7,350	17	1,352	2,847	2,430	2,330	2,832	18
Physics	2,410	4,833	4,905	4,338	5,106	13	1,105	2,688	2,068	1,777	1,906	15
Engineering	5,634	9,610	8,948	10,232	14,119	30	1,790	4,165	3,426	4,123	5,373	29
Earth Sci.	1,263	2,341	2,861	2,181	3,144	7	531	863	1,164	873	1,181	7
Comp./Info. Sci.	567	801	1,590	2,003	2,115	4	288	397	698	832	797	5
Math./Stats.	100	185	272	272	142	1	39	60	83	197	49	1
Interdisc.	167	292	207	341	303	1	38	166	79	43	42	1
TOTAL	17,508	32,559	33,393	35,101	44,050	100	6,447	14,348	13,255	14,149	16,650	100

TABLE 6

Major Equipment Grants by Discipline for 1980 to 1984 Competitions

	Requests (No.)						Awards (No.)					
	1980-81	1981-82	1982-83	1983-84	1984-85	% Total	1980-81	1981-82	1982-83	1983-84	1984-85	% Total
Biology	13	27	10	10	16	16	7	16	5	5	6	17
Psychology					1	1						0
Chemistry	13	25	24	31	32	27	8	13	10	15	12	26
Physics	5	21	11	12	20	15	2	15	4	4	9	15
Engineering	9	43	26	19	28	27	5	25	9	9	11	26
Earth Sci.	8	12	5	11	8	10	4	7	3	7	3	11
Comp./Info. Sci.	1	2	4	2	3	3		1	2	1	1	2
Math./Stats.				1		<1				1		<1
Interdisc.	2	2		2	2	2	1	2		1		2
TOTAL	51	132	80	88	110	100	27	79	33	43	42	100

TABLE 7

Major Equipment Grants by Discipline for the 1980 to 1984 Competitions

	Requests (Current $000)						Awards (Current $000)					
	1980-81	1981-82	1982-83	1983-84	1984-85	% Total	1980-81	1981-82	1982-83	1983-84	1984-85	% Total
Biology	1,920	3,449	1,540	1,868	3,168	15	1,083	1,656	711	764	1,057	14
Psychology					164	1						0
Chemistry	2,042	3,997	4,480	5,942	7,377	29	1,226	1,984	1,752	2,984	2,962	30
Physics	679	3,027	2,066	2,242	4,020	15	296	1,744	760	585	1,856	14
Engineering	1,179	6,067	4,606	3,819	6,136	26	625	3,058	1,671	1,762	2,389	26
Earth Sci.	1,337	2,120	1,083	2,050	1,501	10	485	1,260	670	937	668	11
Comp./Info. Sci.	178	280	706	402	549	3		85	431	217	166	3
Math./Stats.				108		<1				108		<1
Interdisc.	253	287		357	463	2	149	287		176		2
TOTAL	7,588	19,227	14,481	16,788	23,378	100	3,864	10,074	5,968	7,533	9,098	100

TABLE 8

Equipment Profiles of Major Equipment and Major Installation Awards from 1980-81 to 1984-85

	Major Equipment	Major Installation
Reasons (% No.)*		
Replace obsolete or unserviceable equipment	36 - 46	24
On-going research	57 - 65	55
New research	21 - 29	57
Age of Equipment to be replaced (yr.)	12.3 - 13.5	11.4
Quotes from Canadian manufacturers		
% Awards	21 - 29	31
% Dollars	21 - 28	41
Relationships to Regional Centres (% No.)		
Regional Centre	15 - 23	47
Alternate Regional Centre	0 - 2	13
Potential Regional Centre	0 - 2	7
Despite existing Regional Centre	0	2
Not related	74 - 82	32

*Some awards had more than 1 reason
Therefore, % No. may sum to over 100%

TABLE 9

Profile of The Involvement of University, Industry and Government in Major Equipment and Major Installation Awards from 1980-81 to 1984-85

	Major Equipment	Major Installation
Sector Profile (% No.)		
University only	80 - 86	75
Industry and University	6 - 10	8
Research Institutes/Government	6 - 14	18
Awards with University only		
Mean No. participants		
Universities	1.0	1.8
University Departments	1.6 - 2.0	3.1
Awards With Industry Involvement		
Mean No. institutions involved		
Universities	1.7 - 2.7	2.2
University Departments	1.9 - 2.7	4.7
Industries	1.7 - 2.5	4.7
Government Agencies	0.3 - 0.9	1.7
Research Institutes	0.1 - 0.5	1.7

B. INFRASTRUCTURE SUPPORT

B.1 Program Objectives

The objective of the present program of Infrastructure grants is to facilitate the effective use, operation and maintenance of specialized research facilities or resources which would otherwise not be viable in Canadian universities.

B.2 Program Characteristics

The funding required for ongoing support of research facilities and resources in Canadian universities is sought from many sources, of which NSERC Infrastructure grants are a minor component. In 1984-85 NSERC Infrastructure funding totalled 12.7 M$ and was focused on major facilities and resources of a specialized nature, such as culture collections, field stations, marine biological stations, and Slowpoke nuclear reactors. Many smaller facilities are supported through contributions from NSERC Operating Grants.

B.3 The Infrastructure Problem

NSERC recognized the severity of the infrastructure problem in Canadian universities and established a Task Force on Research Infrastructure in December 1983 to provide an in-depth assessment of the problem and to make recommendations to Council. This study, published in 1984, is available on request; the executive summary is reproduced in section C of this document. In brief, the study documented a serious underfunding of research infrastructure in Canadian universities and recommended to NSERC a mechanism for injection of additional resources of the order of 50M$ to maintain the vitality and health of the university research and research training community.

C. EXECUTIVE SUMMARY OF THE REPORT OF THE TASK FORCE ON RESEARCH INFRASTRUCTURE

NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL
TASK FORCE ON RESEARCH INFRASTRUCTURE

EXECUTIVE SUMMARY

The Task Force on Research Infrastructure was established by the Executive Committee of Council in December, 1983, to (1) review the present state of the infrastructure for research in the natural sciences and engineering in Canadian universities, excluding faculty manpower resources, (2) examine the effectiveness of the existing NSERC Infrastructure Grants Program, (3) examine the relative effectiveness of centrally-operated and centrally-funded technical services, (4) examine the current division of responsibility for research infrastructure support between the two levels of government and comment on future trends, and (5) make recommendations on an appropriate future role for NSERC in the support of research infrastructure in the universities.

Definition of Research Infrastructure Costs

For the purpose of this study, research infrastructure costs were defined as the costs associated with the maintenance and operation of specialized equipment and the provision of technical support services which are **used in common** by a number of faculty researchers and their associates.

Methodology

The Task Force used questionnaires, supplemented by visits of the members and NSERC staff, to obtain information on the present state of research infrastructure in the universities. One version of the questionnaire was completed by science and engineering departments in nineteen universities, representing some 66 percent of NSERC grants for 1983-84, and selected on the basis of size, level of research activity, geographic region and language.

This questionnaire sought information on (1) the general profile of the reporting unit, (2) the number and cost of existing infrastructure personnel and sources of salary funding, (3) additional infrastructure personnel needed, (4) recent trends in the level of infrastructure personnel support, and (5) current non-salary infrastructure funding and additional non-salary needs.

An appropriately modified version of the departmental questionnaire was completed for central services, e.g., computer centre, animal quarters, shops, etc., in each of the nineteen universities.

Members of the Task Force also consulted grant selection committees, other committees of Council and Council itself. In addition, meetings were held with the chairmen of three provincial advisory committees on university affairs.

Profile of Researchers

The results of the questionnaires revealed that each professor actively engaged in research has on average 2.2 graduate students, 0.4 postdoctoral fellows or research associates and 0.8 technicians (including research technicians in central services). Using a weight of one-half to convert research faculty and graduate students to full-time equivalent (FTE) researchers, it was found that the technician to FTE researcher ratio in the universities in the natural sciences and engineering is 0.4. This is to be compared with 0.8 at the National Research Council of Canada and 1.1 for three representative industrial research laboratories.

Additional Research Infrastructure Needs

The responses to the questionnaires, extrapolated to the total university system, are summarized in the following table:

Additional Infrastructure Needs	Number of Personnel	Cost $ M	% Increase in Cost Over Present
1. Personnel - science and engineering departments	1023	28.6	72
2. Non-salary - science and engineering departments	-	12.6	74
3. Personnel - central services	165	4.6	29
4. Non-salary - central services	-	2.1	16
5. Total additional needs	1188	47.9	56

An average salary and benefits figure of $28,000 was used to calculate the costs of personnel, which includes PhDs and professional engineers in addition to technicians and research assistants.

It is the Task Force's firm view that the additional needs identified by means of the questionnaires are not overstated and are probably on the conservative side. No allowance has been made for growth in the overall level of research activity in the universities, for development of new programs in emerging areas of scientific and technological opportunity, or for rapid changes in scientific instrumentation.

The Task Force has concluded that there is an urgent need for further infrastructure support of some $48 M for NSERC-sponsored research. It is convinced that our best university researchers would be far more productive and, therefore, much more competitive internationally, if they had the skilled technical manpower needed to ensure maximum use of sophisticated equipment which is kept up-to-date and in a good state of repair. The Task Force believes that the quality of graduate education would be greatly enhanced if highly skilled technical personnel were available to assist in training and supervising students in the use of the equipment and in the execution of complex laboratory procedures. It is also firmly of the view that the university research enterprise would be strengthened if Canada's major research-oriented universities were in a position to maintain the kind of services related to computation, electronics and instrumentation that one finds in leading government and industrial research laboratories.

Regional and Disciplinary Variations in Research Infrastructure

The ratios of technical support staff per million dollars of sponsored research funding are fairly uniform from region to region with the exception of Ontario where this ratio, in relation to NSERC projects and programs, is only one-half that of the rest of the country. Furthermore, the proportion of research infrastructure staff funded by the university, as distinct from external research grants, is lower in Ontario than in any other region.

With respect to infrastructure support by discipline, the most striking observation is the wide variation in the ratio of university-funded to NSERC-funded staff associated with NSERC projects and programs: 7.7 for Chemistry, approximately 3 for Biology, Earth Sciences and Engineering, 1.2 for Physics and 0.2 for Mathematics and Computer Science.

Examination of NSERC's Present Infrastructure Grants Program

The present infrastructure grants program includes the support of specialized research facilities, such as large or special items of equipment, as well as the support of highly skilled technical or professional research support staff who perform functions essential to the maintenance of the research activities of a number of faculty researchers. However, the present program encompasses only a fraction of the total research infrastructure requirements in universities. The 1984-85 Awards Guide explicitly states that Infrastructure Grants "are not intended to assist in the maintenance of facilities standard in a discipline and present in many university departments". Yet, there is considerable evidence that many expensive facilities, which are now standard in a discipline, are not being provided with the maintenance and technical services needed to ensure efficient use.

While there has been a significant increase in infrastructure support by NSERC in recent years (from $7.9 M in 1982-83 to $12.7 M in 1984-85), the Task Force found clear evidence that the present program is not only seriously inadequate in levels of funding but is too restrictive in the categories of expenditure eligible for support.

Centralization vs Decentralization of Technical Services

As might be expected, the extent of centralization at the university level is related to the size of the institution. A single machine shop or electronic shop might be appropriate for a small university but would be less effective in providing specialized services to researchers in large institutions than shops under departmental supervision.

While the Task Force found no tendency towards further centralization at the university level, the same is not true at the departmental level where, to an increasing extent, technical support services and experimental facilities are being brought together to increase efficiency. While in many universities such departmental facilities are still supported from university budgets, user fees or levies against research grants are covering an increasing share of their operating costs. Full cost recovery has become not uncommon.

It is the view of the Task Force that NSERC funding policies should encourage the formation of central services at the departmental level. This will require a change in the regulations requiring the itemization against individual grants of expenditures and the prohibition against pooling grant funds.

Future Trends in University Funding

There is unanimity among senior administrators that universities will have increasing difficulty supporting the infrastructure costs of research. This pessimistic view of the future was shared by the provincial grants committee chairmen whom the Task Force consulted. It follows that if NSERC is to ensure that an effective infrastructure base exists in the universities for the research that it supports in its grants-in-aid programs, it must assume an increasing share of the infrastructure costs. In this context, however, it should be noted that certain provinces, especially the Province of Quebec, are beginning to support in a significant way both basic and applied research in their universities and by so doing have given specific recognition to the infrastructure costs associated with this research.

Mechanisms for Implementation of an Expanded Infrastructure Program

Since the present program of providing infrastructure support for **major facilities of a specialized nature** based on peer evaluation of the excellence of the research program associated with the facility and of need appears to be functioning very satisfactorily, the Task Force has concluded that it should continue. Included in this category are nuclear installations, field stations, marine facilities, regional facilities, major inter-departmental and inter-university research centres or institutes. In the most recent competition, funding for these amount to approximately $7.6 M per year.

A number of approaches were considered by the Task Force for the apportionment of infrastructure funds in support of facilities and services which do **not** belong in the category of major facilities of a specialized nature. This second category includes certain facilities that are funded under the present infrastructure program, as well as some which are currently ineligible. It was concluded that the most satisfactory mechanism would be one involving block grants calculated on the basis of a formula relating to the total of NSERC grants that generate a research infrastructure requirement.

It is proposed that one half of the total block grants be awarded directly to departments in relation to their NSERC funding and that one half be allocated at the university level. Providing infrastructure support to departments would deliver funding closer to the level of the research performer and, therefore, achieve a close correlation with excellence. Futhermore, decisions on the use of such funds would be made at the grassroots level and should be most in tune with real needs. On the other hand, by providing universities with a substantial allocation, they would be in a position to provide better support for centralized facilities, to correct inequities in the departmental allocation in relation to need, to encourage the formation of high-quality interdepartmental facilities and services, and to support new initiatives that require infrastructure funding.

While no mechanism of allocation can fully respond to all infrastructure problems, the Task Force believes that, on balance, a formula allocation that is directed at both the departmental and university levels would be the most flexible and effective.

Based on the existing levels of NSERC-sponsored research activity, it is concluded that $52 M per annum should be directed to this new block grant infrastructure program. This amount comprises $48 M of new funding, the need for which has been documented in this Report, and $4 M transferred from the present Infrastructure Program.

APPENDIX III

DISCIPLINE RESEARCH

INTRODUCTION

The term discipline research is used to describe those NSERC programs which support long-range research activities specifically directed at the generation of new knowledge and its application. Research funded through these programs ranges from fundamental to very applied in nature and is normally adjudicated by discipline peer review committees; there is heavy emphasis on the research excellence of the investigator as the most valid indicator of future success in R and D. The direction of the research programs is selected by the investigator and his/her sense of the most significant and innovative research challenges.

In addition to fostering excellence in R and D, the discipline research programs provide the research environment for the training of graduate students. In many cases they provide not only the research expenses of the students, but also their living expenses through payment of a monthly stipend. The discipline research programs provide over 5,000 students with salary support. An estimated 10,000 students (of whom many are recipients of NSERC scholarships) pursue research activities which are supported through NSERC operating grants.

The time frame covered by this review is 1979-80 to 1984-85, with data for the duration of the first Five-Year Plan (1980-81 to 1984-85) referenced to the year immediately preceding implementation of the plan (1979-80).

Expenditures through these programs totalled $143M in 1984-85. Table 1 provides a detailed breakdown for the period 1979-80 to 1984-85.

TABLE 1

Expenditures for Discipline Research
(Thousands of Current Dollars)

	BASE 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
Discipline Research Grants						
Operating Grants						
- Individual	67,566	75,508	84,659	100,468	114,174	127,647
- Team	1,781	2,072	2,588	3,222	3,548	3,532
- Co-op	671	1,143	1,894	1,589	854	169
- Project	3,123	3,524	4,140	5,183	6,620	6,452
- University Research Fellows	-	847	1,912	2,832	3,941	4,752
Steacie Fellowships	102	299	425	412	384	435
Total Discipline Research	73,243	83,393	95,618	113,706	129,521	142,987

A. OPERATING GRANTS - INDIVIDUAL AND TEAM

A.1 Program Objectives

The overall objective of the Operating Grants Program is "to assist in the promotion and maintenance of a diverse and high quality research capability in the natural sciences and engineering". This is carried out primarily by means of two types of grants - Individual and Team Operating Grants (some research programs in subatomic physics are treated separately in Section B). The specific objective of these grants is to:

- foster research excellence for individuals and groups of researchers and provide a stimulating environment for research training.

A.2 Program Characteristics

The Operating Grants Program is at the core of NSERC's support for research excellence and provides funds for on-going research endeavours as opposed to projects. Grants are awarded primarily on the basis of the demonstrated track record of the investigators and their potential for continued significant contributions to science/engineering, taking into consideration the financial requirements of the proposed research.

The major attributes of this program are (i) the continuity of support provided to productive individuals and (ii) the freedom provided to pursue new directions of investigation. These two characteristics are considered essential for the vitality of the university research and research training endeavour, and the ability of the community to adapt to new challenges in the future.

A.3 Introduction to Data and Analysis

A simple inspection of much of the data provided in the following pages can be misleading without an understanding of the process of financial allocation and application evaluation. Some of the many factors which contribute to the complexity are (i) the process whereby NSERC allocates funds to a discipline area, (ii) the fact that up to 50% to 60% of the community may be on two or three year grants in a given year, (iii) the diverse approaches to evaluation and funding amongst the peer-review committees and (iv) the different degrees of turnover (new researchers and people leaving) in some of the discipline areas. These factors will be discussed as needed in the text of this appendix, but some comment on the discipline allocation procedure is appropriate at this point.

Each discipline committee receives a budgetary allocation that takes into account (i) the number of returning applicants and the funding levels that they held through their previous grant, (ii) the number of new applicants and the funding level provided to new applicants in that discipline in previous competitions and (iii) any special budget adjustment made by NSERC. Normally, NSERC adjusts each discipline budget to compensate for the impacts of inflation and in recent years has made a number of special budgetary increases to selected disciplines which were considered to be particularly underfunded. Council's Allocations Committee itself is undertaking an extensive study of the allocations to the various disciplines. This has proved to be a very complex and difficult task and work on this is expected to continue for some time.

A.4 Community Size and Program Expenditures

The size of the community supported through individual and team grants has increased by about 11% over the period under study, from 5344 awards to 5940 awards (see Figure 1) with a concomitant increase in expenditures of 21% in constant 1984 $. Team grants have continued to represent a very small, but slightly increasing percentage of the total number of awards (from 1.2% to 1.7%), but the dominance of individual operating grants continues; thus to a first approximation, the success rates and funding levels for individual operating grants provide a measure of the discipline characteristics.

Table 2 provides an overview of the change in the number and level of operating grants (note: project grants are included in this table).

TABLE 2

Total Funding Levels for Individual, Team and Project Operating Grants
1979-80 to 1984-85
(Current $)

	Individual Op. Grants		Team Op. Grants		Project Op. Grants		Total
	#	$000	#	$000	#	$000	($000)
1979-80	5,278	67,566	66	1,781	57	3,123	72,470
1980-81	5,299	75,508	79	2,072	55	3,524	81,104
1981-82	5,372	84,659	92	2,588	61	4,140	91,387
1982-83	5,515	100,468	107	3,222	68	5,183	108,874
1983-84	5,748	114,174	103	3,548	63	6,620	124,342
1984-85	5,840	127,647	100	3,532	69	6,452	137,631

A.5 Discipline Distribution of NSERC Support

The NSERC Operating Grants Program is primarily responsive in nature, in that the number of grants awarded is a response to the number of high quality applications. Thus, when one research area grows relative to others, the number of applications and awards will increase, providing the applicants meet normal standards of excellence.

Figure 1

Growth in the Number of NSERC Operating Grants (Individual and Team)
1979-80 to 1984-85

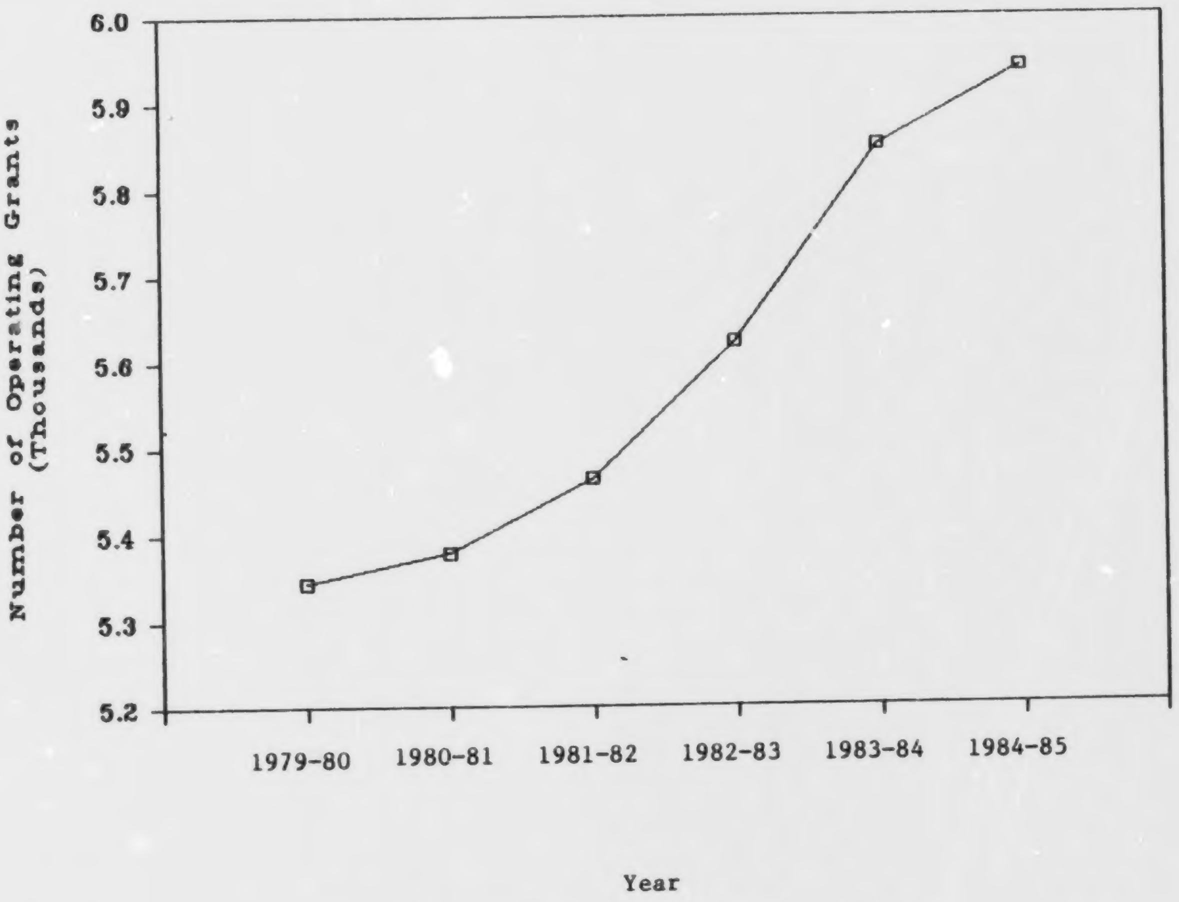

Figure 2 provides an overview of the net change in the number and percentage of grants by discipline grouping* between 1979-80 and 1984-85. The engineering disciplines have seen the largest absolute growth, with computing and information science having the largest percentage growth. The increasing demands for graduate and undergraduate instruction in these areas make these observations easily understood. The increase in psychology is more difficult to understand, but it may well be a combination of a number of factors such as:

- increase of interest in neurosciences or other areas of NSERC jurisdiction
- slight shifting of the jurisdiction of the three Councils vis-à-vis psychology.

The decrease in the physics and chemistry communities should be treated with some caution. The absolute and percentage change is relatively small and the major push by NSERC for increased "selectivity" (see section A.6) may account for some of the observed changes (e.g. discouragement of a significant sector of the community from applying for NSERC grants because of the stringent standards of excellence required for NSERC support). Regardless, it is known that the research community in chemistry and physics is aging faster than most other discipline areas (see Table 3) and that there are very few faculty positions opening in these disciplines.

The transfer by NSERC of certain sub-discipline areas between these groupings may also account for some of the changes - i.e. the transfer of geotechnical research from earth sciences to civil engineering and the gradual transfer of some applications in applied mathematics to engineering.

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* Engineering - Civil Engineering, Chemical and Metallurgical Engineering, Mechanical Engineering, Electrical Engineering, Industrial Engineering

Physics - Physics, Subatomic Physics, Space and Astronomy

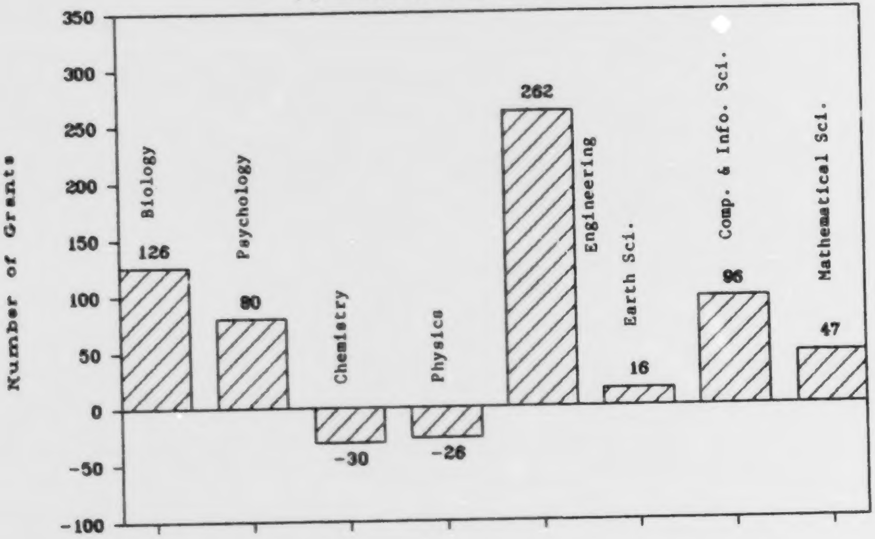
Biology - Animal Biology, Plant Biology, Cell Biology and Genetics, Population Biology

Mathematical Sciences - Pure and Applied Mathematics, Statistical Sciences.

Figure 2

Net Change in the Discipline Distribution of the Community Funded by NSERC
(Individual and Team Operating Grants Only) 1979-80 to 1984-85

(A) Increase/Decrease by Number



(B) Increase/Decrease by Percentage

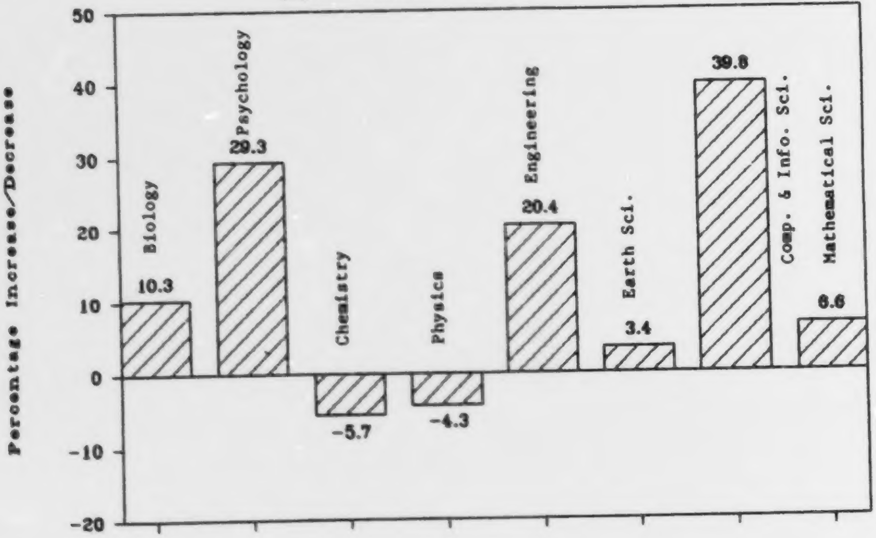


TABLE 3

Average "Maturity" (Years from Bachelor's Degree) of Recipients of Individual Operating Grants

	1979-80	1984-85	Change
Animal Biology	20.3	22.5	2.2
Cell Biology & Genetics	18.8	21.3	2.5
Plant Biology	21.7	23.5	1.8
Population Biology	18.8	21.5	2.7
Psychology	16.0	18.8	2.7
Chemistry	21.3	24.6	3.4
Physics	21.2	25.1	3.9
Subatomic Physics	24.9	26.9	2.1
Space & Astronomy	20.1	22.7	2.6
Chem. & Metallurgical Eng.	21.7	23.7	2.0
Civil Eng.	19.4	22.6	3.2
Electrical Eng.	19.3	21.9	2.6
Mechanical Eng.	20.1	22.9	2.8
Industrial Eng.	18.5	19.3	0.8
Earth Sciences	19.1	21.5	2.4
Computing & Information Sci.	15.0	17.4	2.4
Mathematics	19.0	22.7	3.7
Statistical Sciences	19.0	21.0	2.0
NSERC	19.6	22.2	2.6
Estimated average age of grant recipients*	42.5	45	

* Assuming receipt of a Bachelor's degree at age 23.

As a result of the relative changes in the size and nature of the community supported by NSERC, there have been shifts in the funding allocated to the various discipline groupings. These changes are shown in Table 4 and Figure 3. Given the size of the discipline communities supported in each area, the seemingly small incremental changes in Figure 3 represent significant growth as shown in Table 4.

TABLE 4

Change in Funding Distribution by Discipline Grouping
(Individual and Team Grants Only) 1979-80 to 1984-85 (Constant 1984 $)

	1979-80		1984-85		"Growth"
	$000	%	$000	%	%
Biology	28,267.9	26.1	34,631.7	26.5	22.5
Psychology	5,258.5	4.8	6,484.6	5.0	23.3
Chemistry	14,959.7	13.8	16,309.9	12.5	9.0
Physics	14,705.3	13.6	15,692.4	12.0	6.7
Engineering	25,537.8	25.4	33,373.6	25.6	30.7
Earth Sciences	9,394.9	8.7	10,608.2	8.1	12.9
Comp./Info. Sciences	4,188.2	3.9	6,162.0	4.7	47.1
Math. Sciences	5,967.8	5.5	7,258.9	5.6	21.6
Total *	108,459.9		130,521.3		20.3

* Interdisciplinary support not included.

Tables 5 to 10 give a full breakdown of the number and level of awards in all disciplines supported by NSERC from 1979-80 to 1984-85:*

Table 5: Number of Individual Operating Grants
Table 6: Expenditures on Individual Operating Grants (Current $)
Table 7: Expenditures on Individual Operating Grants by Grant Selection Committee (Constant $)
Table 8: Number of Team Operating Grants
Table 9: Expenditures on Team Operating Grants (Current $)
Table 10: Expenditures on Team Operating Grants (Constant $)

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* Note: - The selection committee for the Global Atmospheric Research Program (GARP) was phased out in 1981-82.
- Nuclear Physics and Intermediate Energy Physics Selection Committees were amalgamated in 1983-84, with High Energy Physics added in 1984-85 to include all Subatomic Physics within one committee.

Figure 3

Percentage Distribution of Operating Grants (Individual and Team) Awarded by Discipline Grouping

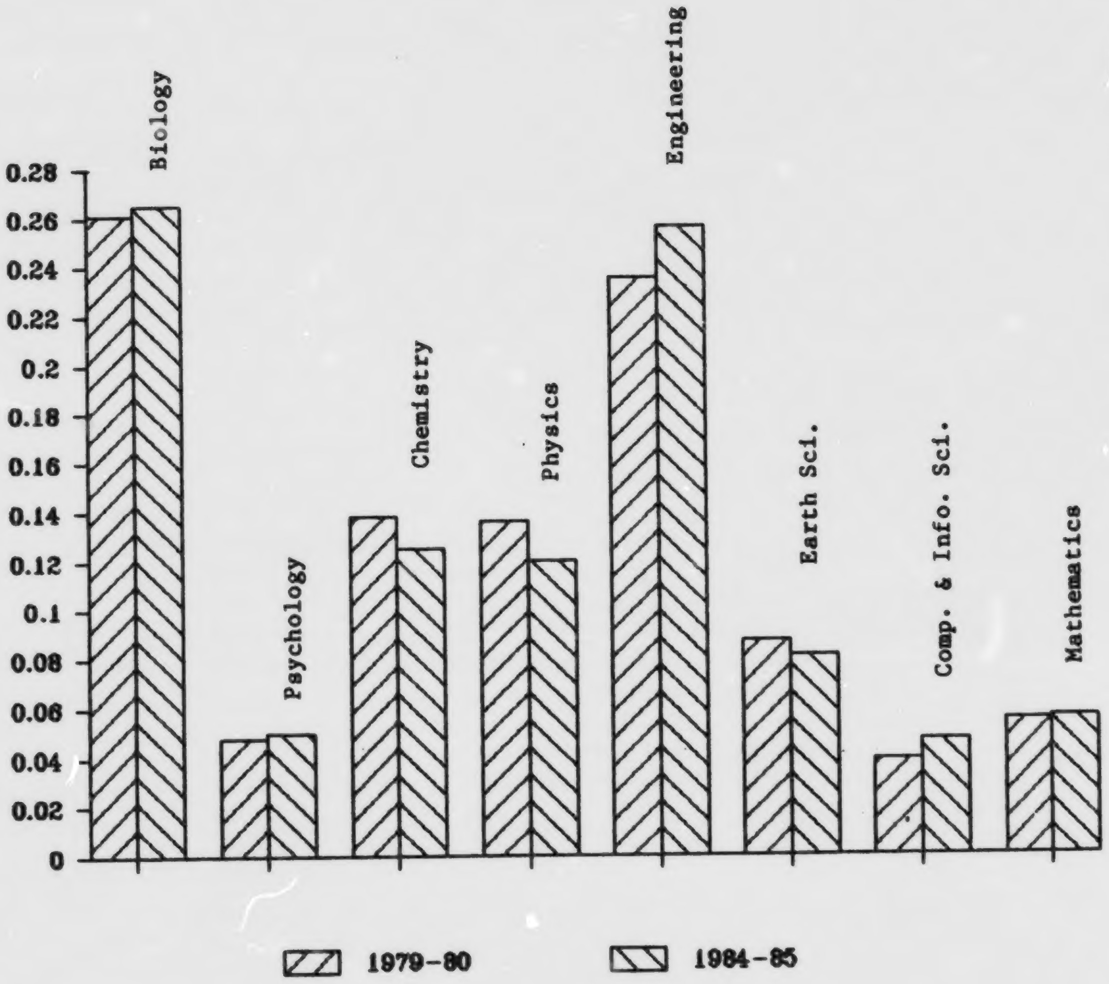


TABLE 5

Individual Operating Grants by Grant Selection Committee
1979-80 to 1984-85 Competitions + Instalments

Grant Selection Committee	Awards (No.)					
	79-80	80-81	81-82	82-83	83-84	84-85
Animal Biol.	322	327	328	331	359	367
Cell Biol.	352	354	358	349	344	361
Plant Biol.	212	215	223	230	242	253
Population Biol.	325	311	319	327	329	345
Psychology	270	282	306	326	342	342
Chemistry	520	508	518	528	505	491
Physics	415	422	405	402	395	391
Nucl. Sci.	57	49	44	43	38	39
Int. Ener. Phys.						
High Ener. Phys.			1	1	1	1
Space/Astronomy	123	122	125	132	134	133
G.A.R.P.	2	2				
Chem./Met. Eng.	310	321	328	318	338	337
Civil Eng.	266	301	305	309	343	358
Elec. Eng.	324	326	324	342	373	384
Mech. Eng.	286	275	280	275	291	321
Industrial Eng.	79	65	66	77	96	116
Earth Sciences	459	458	453	489	493	480
Comp./Info. Sci.	239	251	267	280	321	336
Mathematics	634	576	530	544	585	550
Statistics	74	122	170	174	182	203
Interdisc.	9	12	22	38	37	32
OVERALL	5,278	5,299	5,372	5,515	5,748	5,840

TABLE 6

Individual Operating Grants by Grant Selection Committee 1979-80 to 1984-85 Competitions + Instalments

Grant Selection Committee	Awards (current $)					
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Animal Biol.	4,479,398	5,081,488	5,780,819	6,867,988	7,702,380	8,793,857
Cell Biol.	5,884,147	6,564,938	7,457,777	8,474,411	9,179,751	10,447,874
Plant Biol.	3,369,080	3,831,868	4,240,915	5,200,919	5,949,987	6,703,687
Population Biol.	4,073,649	4,674,591	5,331,541	6,430,319	7,222,832	8,054,381
Psychology	3,299,358	3,713,477	4,261,904	5,062,802	5,721,820	6,282,927
Chemistry	9,360,037	10,175,573	11,560,983	13,637,424	14,922,545	16,104,151
Physics	5,847,743	6,383,901	6,994,106	8,130,502	8,925,966	9,700,120
Nucl. Sci.	1,040,000	1,186,650	1,161,650	1,252,154	1,346,931	1,326,800
Int. Ener. Phys.						
High Ener. Phys.			15,000	21,000	16,000	20,000
Space/Astronomy	1,809,878	1,943,302	2,223,586	2,726,226	2,881,003	3,187,128
G.A.R.P.	35,190	38,638				
Chem./Met. Eng.	4,184,102	4,716,039	5,321,838	6,072,292	7,123,627	8,142,105
Civil Eng.	3,279,375	3,988,025	4,374,227	5,211,028	6,648,271	7,652,780
Elec. Eng.	3,993,766	4,453,933	4,832,438	5,893,531	7,041,577	7,898,168
Mech. Eng.	3,630,021	3,873,643	4,338,063	4,996,948	5,907,831	6,914,285
Industrial Eng.	763,016	719,226	880,511	1,114,735	1,452,857	1,847,157
Earth Sciences	5,927,196	6,684,045	7,394,148	8,890,165	9,782,941	10,553,630
Comp./Info. Sci.	2,659,676	3,015,970	3,425,401	4,180,124	5,341,073	6,136,577
Mathematics	3,405,917	3,581,263	3,718,091	4,504,808	4,916,417	5,479,997
Statistics	409,798	704,940	1,012,449	1,179,807	1,432,558	1,754,331
Interdisc.	114,929	176,588	333,639	621,273	658,121	647,669
OVERALL	67,566,276	75,508,098	84,659,086	100,468,456	114,174,488	127,647,624

TABLE 7

Individual Operating Grants by Grant Selection Committee 1979-80 to 1984-85 Competitions + Instalments

Grant Selection Committee	Awards (Constant 1984 $) 1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Animal Biol.	7,004,166	7,113,372	7,251,170	7,644,071	8,087,499	8,793,857
Cell Biol.	9,200,688	9,189,994	9,354,663	9,432,019	9,638,739	10,447,874
Plant Biol.	5,268,028	5,364,079	5,319,592	5,788,623	6,247,486	6,703,687
Population Biol.	6,369,721	6,543,773	6,687,618	7,156,945	7,583,974	8,054,381
Psychology	5,159,008	5,198,348	5,345,919	5,634,899	6,007,911	6,282,927
Chemistry	14,635,728	14,244,378	14,501,519	15,178,453	15,668,672	16,104,151
Physics	9,143,765	8,936,568	8,773,057	9,049,249	9,372,264	9,700,120
Nucl. Sci.	1,626,186	1,661,144	1,457,116	1,393,647	1,414,278	1,326,800
Int. Ener. Phys.	0	0	0	0	0	0
High Ener. Phys.	0	0	18,815	23,373	16,800	20,000
Space/Astronomy	2,829,998	2,720,351	2,789,155	3,034,290	3,025,053	3,187,128
G.A.R.P.	55,024	54,088	0	0	0	0
Chem./Met. Eng.	6,542,429	6,601,794	6,675,447	6,758,461	7,479,808	8,142,105
Civil Eng.	5,127,762	5,582,677	5,486,812	5,799,874	6,980,685	7,652,780
Elec. Eng.	6,244,812	6,234,883	6,061,569	6,559,500	7,393,656	7,898,168
Mech. Eng.	5,676,046	5,422,558	5,441,449	5,561,603	6,203,223	6,914,285
Industrial Eng.	1,193,082	1,006,816	1,104,469	1,240,700	1,525,500	1,847,157
Earth Sciences	9,268,001	9,356,727	9,274,850	9,894,754	10,272,088	10,553,630
Comp./Info. Sci.	4,158,776	4,221,936	4,296,652	4,652,478	5,608,127	6,136,577
Mathematics	5,325,628	5,013,267	4,663,652	5,013,851	5,162,238	5,479,997
Statistics	640,777	986,817	1,269,965	1,313,125	1,504,186	1,754,331
Interdisc.	179,708	247,198	418,500	691,477	691,027	647,669
OVERALL	105,649,332	105,700,766	106,192,125	111,821,392	119,883,212	127,647,624

TABLE 8

Team Operating Grants by Grant Selection Committee
1979-80 to 1984-85 Competitions + Instalments

Grant Selection Committee	Awards (No.)					
	79-80	80-81	81-82	82-83	83-84	84-85
Animal Biol.	6	6	6	7	7	10
Cell Biol.	5	5	6	7	6	5
Plant Biol.	1	3	3	5	6	6
Population Biol.	2	3	1	4	3	4
Psychology	3	5	7	11	10	11
Chemistry	10	11	12	11	11	9
Physics	5	5	5	11	7	8
Nucl. Sci.	4	5	5	7	8	7
Int. Ener. Phys.		1	1	1		
High Ener. Phys.						
Space/Astronomy	2	2	2	3	3	3
G.A.R.P.						
Chem./Met. Eng.	4	4	4	3	4	4
Civil Eng.	1	3	7	7	6	7
Elec. Eng.	7	9	13	7	7	6
Mech. Eng.	6	7	10	10	11	7
Industrial Eng.	1	2	3	3	5	6
Earth Sciences	7	4	2	1	2	2
Comp./Info. Sci.	2	4	4	4	3	1
Mathematics			1	3	3	1
Statistics						1
Interdisc.				2	1	2
OVERALL	66	79	92	107	103	100

TABLE 9

Team Operating Grants by Grant Selection Committee
1979-80 to 1984-85 Competitions + Instalments

Grant Selection Committee	Awards (current $) 1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Animal Biol.	83,173	84,774	81,012	111,477	112,108	229,720
Cell Biol.	126,136	142,996	169,295	177,246	168,392	172,481
Plant Biol.	32,000	52,136	33,700	68,324	97,299	105,607
Population Biol.	26,496	44,046	13,200	85,996	103,880	124,074
Psychology	62,837	96,474	114,021	165,736	168,155	201,621
Chemistry	205,022	204,449	230,015	273,237	304,480	205,727
Physics	305,576	310,370	335,147	628,831	587,584	627,959
Nucl. Sci.	298,000	415,500	581,000	626,000	748,360	656,000
Int. Ener. Phys.		26,500	34,150	33,668		
High Ener. Phys.						
Space/Astronomy	66,000	73,000	77,200	123,751	166,102	174,407
G.A.R.P.						
Chem./Met. Eng.	88,790	97,491	82,985	82,835	110,383	73,128
Civil Eng.	32,913	31,000	125,100	144,121	132,219	173,412
Elec. Eng.	118,528	154,311	257,600	174,322	267,860	235,964
Mech. Eng.	223,000	237,116	309,563	338,210	384,650	349,749
Industrial Eng.	15,000	16,000	34,400	44,000	71,260	86,874
Earth Sciences	79,793	53,660	27,125	22,551	51,940	54,537
Comp./Info. Sci.	18,200	31,800	78,360	92,185	42,146	25,460
Mathematics			3,722	19,299	25,397	15,582
Statistics						9,000
Interdisc.				10,000	5,300	10,565
OVERALL	1,781,464	2,071,623	2,587,595	3,221,789	3,547,515	3,531,867

TABLE 10

Team Operating Grants by Grant Selection Committee
1979-80 to 1984-85 Competitions + Instalments

Grant Selection Committee	Awards (current $)					
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Animal Biol.	130,053	118,672	101,617	124,074	117,713	229,720
Cell Biol.	197,231	200,174	212,355	197,275	176,812	172,481
Plant Biol.	50,036	72,983	42,272	76,045	102,164	105,607
Population Biol.	41,430	61,658	16,557	95,714	109,074	124,074
Psychology	98,254	135,050	143,022	184,464	176,563	201,621
Chemistry	320,581	286,200	288,519	304,113	319,704	205,727
Physics	477,811	434,475	420,392	699,889	616,963	627,959
Nucl. Sci.	465,965	581,642	728,777	696,738	785,778	656,000
Int. Ener. Phys.	0	37,096	42,836	37,472	0	0
High Ener. Phys.	0	0	0	0	0	0
Space/Astronomy	103,200	102,190	96,836	137,735	174,407	174,407
G.A.R.P.	0	0	0	0	0	0
Chem./Met. Eng.	138,836	136,474	104,092	92,195	115,902	73,128
Civil Eng.	51,464	43,396	156,919	160,407	138,830	173,412
Elec. Eng.	185,335	216,014	323,121	194,020	281,253	235,964
Mech. Eng.	348,692	331,929	388,300	376,428	403,883	349,749
Industrial Eng.	23,455	22,398	43,150	48,972	74,823	86,874
Earth Sciences	124,768	75,116	34,024	25,099	54,537	54,537
Comp./Info. Sci.	28,458	44,516	98,291	102,602	44,253	25,460
Mathematics	0	0	4,669	21,480	26,667	15,582
Statistics	0	0	0	0	0	9,000
Interdisc.	0	0	0	11,130	5,565	10,565
OVERALL	2,785,568	2,899,982	3,245,750	3,585,851	3,724,891	3,531,867

A.6 Selectivity and Average Grant Levels

It is evident from the preceding data that the average level of support provided to grantees varies significantly from discipline to discipline. The average grant is not simply an indication of the cost of doing research in each discipline area, but it also includes a combination of complex factors such as

- the "maturity" of the discipline (e.g. as indicated by the relative influx of new applicants and stability of the senior research community)
- the quality of the research
- the extent to which the committee is selective in reallocating research support from the relatively less productive to the more productive researchers. This can be examined in part by looking at the success rates by discipline.

This complex blend of factors influencing average grant levels has resulted in intensive study of the funding needs and patterns of various disciplines by the Allocations Committee. Amongst other things it has attempted to (i) better understand the interplay of selectivity, average grant and support of excellence in research and (ii) assess priorities for future budget adjustments to certain discipline areas.

Data on funding and success rates by discipline over the study period are given in Tables 11 to 14. These data are reported for those applications considered in the annual grants competition only and exclude instalments (commitments of instalment payments for multi-year grants). In reviewing these data, caution must be exercised because of the existence of multi-year grants. Some disciplines review a higher proportion of their community each year than others and in certain instances there is uneven distribution of the most productive grantees (e.g. all of the outstanding researchers could be grouped in one of three competition years). What is revealed, however, is an overall trend to decreasing success rates, and some significant variations from discipline to discipline.

The success rate of applicants is one aspect of selectivity that NSERC has scrutinized during the first Five-Year Plan. The need to provide improved funding levels for the most active and productive researchers from a limited financial resource led to the introduction of a "merit supplement" whereby, over the period 1982-83 to 1984-85, selection committees had access to special funds to increase the grants of the most meritorious researchers, providing that those same researchers had already received increases from the committee budget well above the inflationary increase provided to the committees. This has resulted in a marked redistribution of funds amongst grantees and less continuity of funding than in the past in some disciplines where capable researchers are at, or close to, the cut-off threshold.

TABLE 11

Funding Rates ($) for Individual Operating Grants, 1979-80 to 1984-85 Competitions (No Instalments Included)

Grant Selection Committee	Funding Rate ($ Awarded/$ Requested) 79-80	80-81	81-82	82-83	83-84	84-85
Animal Biol.	0.56	0.48	0.34	0.52	0.46	0.46
Cell Biol.	0.56	0.48	0.46	0.55	0.49	0.46
Plant Biol.	0.54	0.50	0.41	0.50	0.51	0.47
Population Biol.	0.44	0.42	0.40	0.49	0.48	0.46
Psychology	0.45	0.46	0.49	0.50	0.50	0.52
Chemistry	0.51	0.51	0.52	0.56	0.54	0.52
Physics	0.54	0.53	0.51	0.58	0.57	0.54
Nucl. Sci.	0.62	0.68	0.65	0.67	0.69	0.59
Int. Ener. Phys.						
High Ener. Phys.			0.75	0.97	1.00	
Space/Astronomy	0.53	0.56	0.58	0.61	0.60	0.64
G.A.R.P.						
Chem./Met. Eng.	0.54	0.53	0.48	0.55	0.55	0.53
Civil Eng.	0.61	0.56	0.48	0.65	0.62	0.54
Elec. Eng.	0.54	0.56	0.53	0.55	0.57	0.52
Mech. Eng.	0.56	0.54	0.50	0.58	0.59	0.56
Industrial Eng.	0.50	0.54	0.50	0.51	0.57	0.52
Earth Sciences	0.52	0.50	0.46	0.52	0.50	0.51
Comp./Info. Sci.	0.53	0.51	0.51	0.55	0.54	0.50
Mathematics	0.41	0.53	0.49	0.51	0.53	0.56
Statistics	0.44	0.41	0.41	0.44	0.50	0.52
Interdisc.	0.42	0.36	0.28	0.32	0.30	0.28
OVERALL	0.52	0.51	0.48	0.54	0.53	0.51

TABLE 12

Success Rates (No.) for Individual Operating Grants, 1979-80 to 1984-85 Competitions (No Instalments Included)

Grant Selection Committee	Success Rate (No. Awarded/No. Requested)					
	79-80	80-81	81-82	82-83	83-84	84-85
Animal Biol.	0.81	0.73	0.69	0.78	0.73	0.74
Cell Biol.	0.78	0.82	0.81	0.82	0.80	0.77
Plant Biol.	0.75	0.76	0.71	0.74	0.73	0.73
Population Biol.	0.67	0.65	0.64	0.73	0.74	0.74
Psychology	0.79	0.83	0.87	0.90	0.88	0.76
Chemistry	0.78	0.82	0.87	0.88	0.80	0.73
Physics	0.86	0.92	0.89	0.90	0.82	0.78
Nucl. Sci.	0.97	0.96	0.98	1.00	0.97	0.95
Int. Ener. Phys.						
High Ener. Phys.			1.00	1.00	1.00	
Space/Ast.	0.94	0.96	0.95	0.96	0.99	0.91
G.A.R.P.						
Chem./Met. Eng.	0.87	0.93	0.95	0.90	0.93	0.83
Civil Eng.	0.89	0.87	0.93	0.91	0.90	0.81
Elec. Eng.	0.94	0.97	0.92	0.93	0.95	0.83
Mech. Eng.	0.88	0.94	0.93	0.91	0.89	0.84
Industrial Eng.	0.83	0.92	0.80	0.84	0.86	0.83
Earth Sciences	0.88	0.88	0.80	0.89	0.81	0.79
Comp./Info. Sci.	0.86	0.87	0.90	0.86	0.89	0.81
Mathematics	0.79	0.86	0.90	0.92	0.95	0.75
Statistics	0.88	0.92	0.91	0.95	0.90	0.88
Interdisc.	0.64	0.53	0.56	0.63	0.52	0.48
OVERALL	0.83	0.86	0.84	0.87	0.85	0.78

TABLE 13

Funding Rates ($) for Team Operating Grants, 1979-80 to 1984-85 Competitions (No Instalments Included)

Grant Selection Committee	Funding Rate ($ Awarded/$ Requested)					
	79-80	80-81	81-82	82-83	83-84	84-85
Animal Biol.	0.44	0.42	0.18	0.28	0.16	0.41
Cell Biol.	0.46	0.36	0.21	0.28	0.28	0.39
Plant Biol.	0.72	0.74	0.35	0.26	0.73	0.36
Population Biol.	0.67	0.24	0.00	0.37	0.24	0.44
Psychology	0.41	0.24	0.23	0.46	0.33	0.17
Chemistry	0.49	0.44	0.54	0.53	0.55	0.33
Physics	0.76	0.76	0.70	0.68	0.87	0.79
Nucl. Sci.	0.79	0.78	0.80	0.70	0.71	0.75
Int. Ener. Phys.		0.70				
High Ener. Phys.						
Space/Astronomy	0.70	0.63	0.58	0.83	0.82	0.00
G.A.R.P.						
Chem./Met. Eng.	0.64	0.00	0.51	0.64	0.40	0.37
Civil Eng.	0.00	0.29	0.56	0.69	0.44	0.72
Elec. Eng.	0.60	0.44	0.35	0.16	0.67	0.32
Mech. Eng.	0.64	0.48	0.25	0.51	0.49	0.00
Industrial Eng.	0.62	0.31	0.76	0.42	0.59	0.36
Earth Sciences	0.41	0.44	0.21	0.00	0.32	0.00
Comp./Info. Sci.	0.73	0.55	0.51	0.35	0.55	0.58
Mathematics	0.00	0.00	0.67	0.26	0.32	
Statistics						0.19
Interdisc.	0.00	0.00	0.00	0.13	0.00	0.06
OVERALL	0.59	0.52	0.49	0.49	0.52	0.51

TABLE 14

Success Rates (No.) for Team Operating Grants, 1979-80 to 1984-85 Competitions (No Instalments Included)

Grant Selection Committee	Success Rate (No. Awarded/No. Requested)					
	79-80	80-81	81-82	82-83	83-84	84-85
Animal Biol.	0.80	0.60	0.33	0.50	0.30	0.60
Cell Biol.	1.00	0.33	0.50	0.63	0.33	0.50
Plant Biol.	1.00	1.00	1.00	0.67	1.00	0.50
Population Biol.		0.67	0.00	0.50	0.50	1.00
Psychology	0.67	0.50	0.50	0.78	0.60	0.40
Chemistry	0.71	0.75	0.88	0.75	0.67	0.67
Physics	0.67	0.83	1.00	0.86	1.00	1.00
Nucl. Sci.	1.00	1.00	1.00	1.00	0.89	1.00
Int. Ener. Phys.		1.00				
High Ener. Phys.						
Space/Astronomy	1.00	1.00	1.00	1.00	1.00	0.00
G.A.R.P.						
Chem./Met. Eng.	1.00	0.00	1.00	1.00	0.50	1.00
Civil Eng.	0.00	0.60	1.00	1.00	0.60	1.00
Elec. Eng.	1.00	0.89	0.80	0.75	1.00	0.25
Mech. Eng.	0.86	0.71	0.71	0.83	1.00	0.00
Industrial Eng.	1.00	1.00	1.00	1.00	0.80	0.75
Earth Sciences	0.80	0.80	0.50	0.00	0.50	0.00
Comp./Info. Sci.	1.00	1.00	1.00	1.00	0.60	0.50
Mathematics	0.00	0.00	1.00	1.00	1.00	
Statistics						0.50
Interdisc.	0.00	0.00	0.00	0.50	0.00	0.33
OVERALL	0.77	0.72	0.72	0.75	0.63	0.60

Figure 4

Trends in Average Grant and Success Rate by Discipline Grouping 1979 to 1984

Key to Figure

Four graphs are presented for each discipline grouping.

- Average Grant by Year (all grants, competition and instalment)

  Note - four different scales are used to ensure that trends are clearly visible (in constant 1984 $):

- $5,000 - $15,000	Mathematics and Statistics
- $15,000 - $25,000	Psychology Earth Sciences Computing and Information Sciences Engineering
- $20,000 - $30,000	Physics Biology
- $25,000 - $35,000	Chemistry

- Indexed Average Grant by Year - the ratio of the discipline average to that of all NSERC disciplines x 100

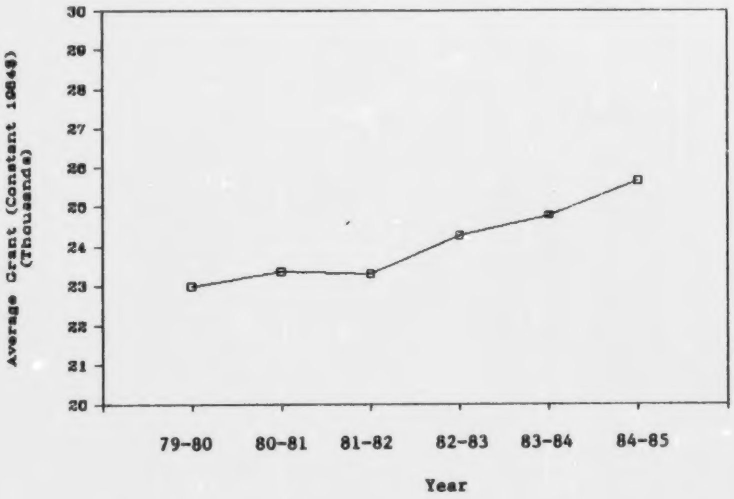
  Note - three different scales are used to ensure that trends are clearly visible:

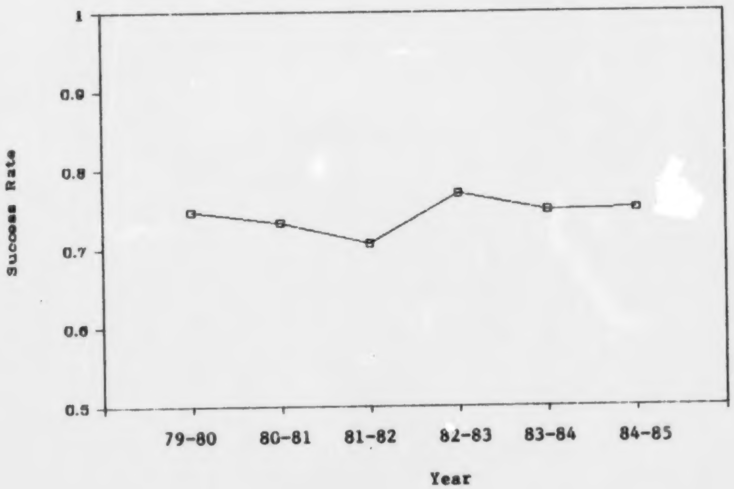
- 30 - 110	Mathematics and Statistics
- 70 - 140	Computing and Information Sciences
- 90 - 160	All others

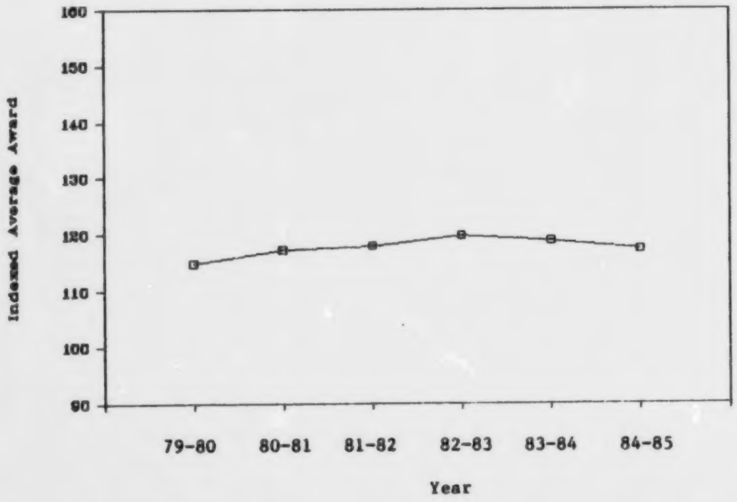
- Success Rate by Year - success rate (by number) of all applications considered in the competition

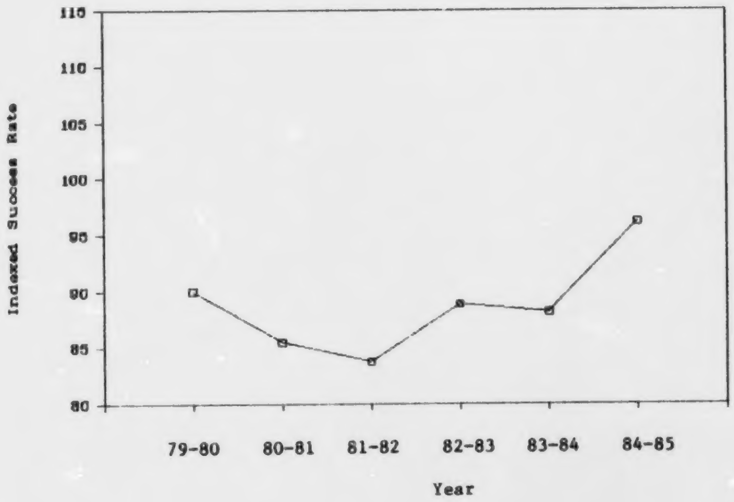
- Indexed Success Rate by Year - the ratio of the discipline success rate to that of all NSERC x 100

BIOLOGY: 1979–1984

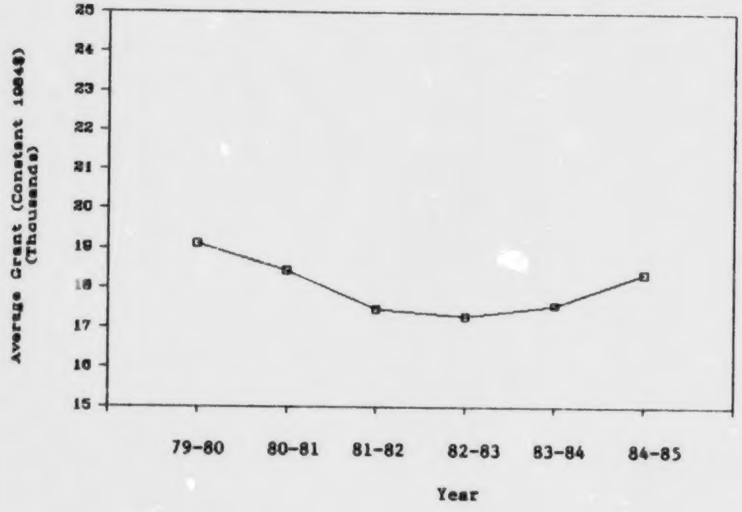


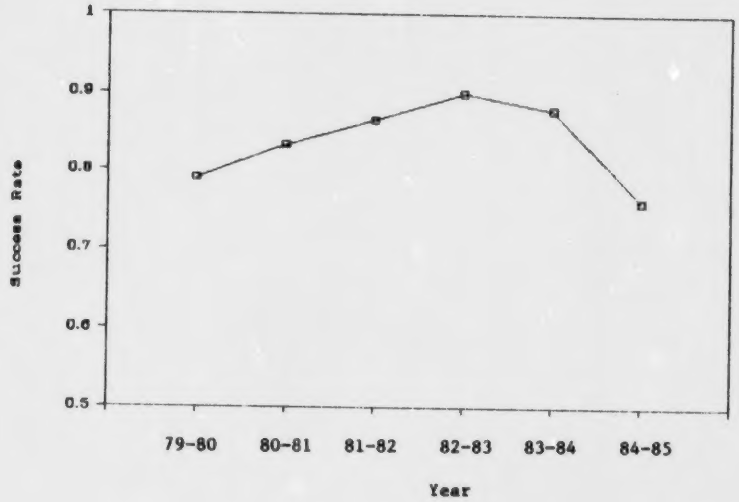


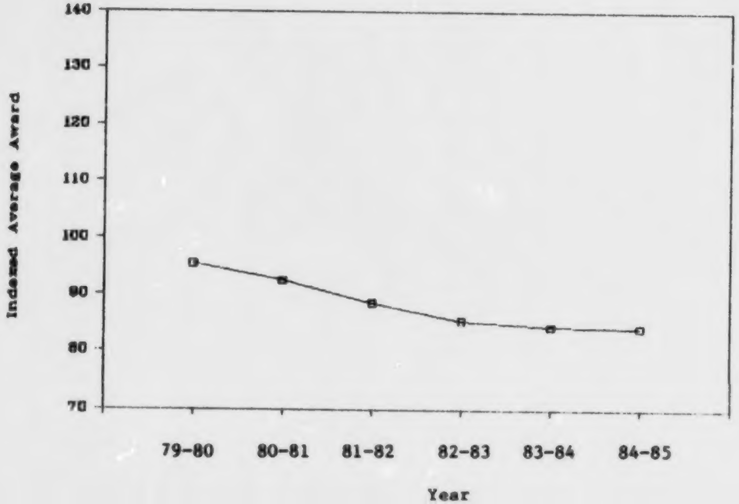


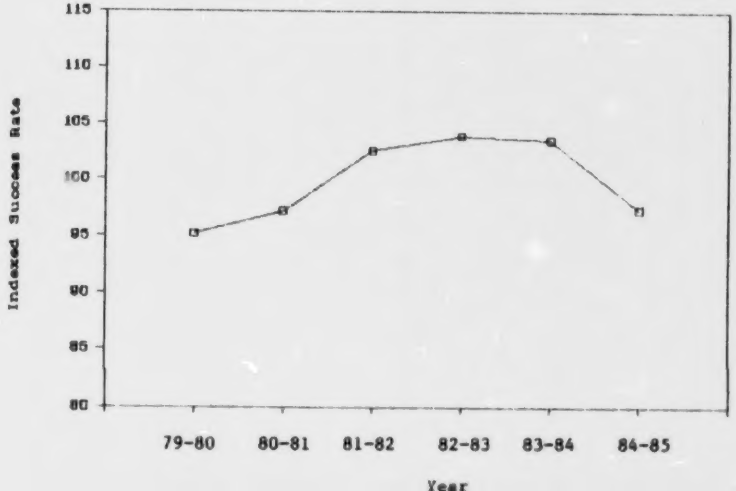


PSYCHOLOGY: 1979-1984









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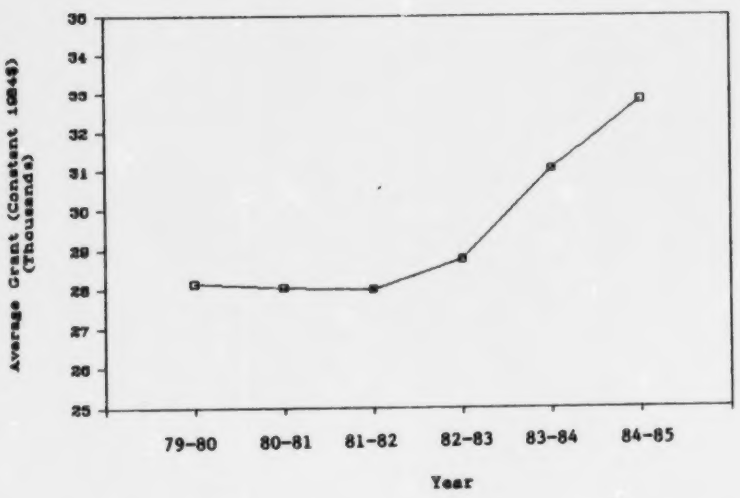
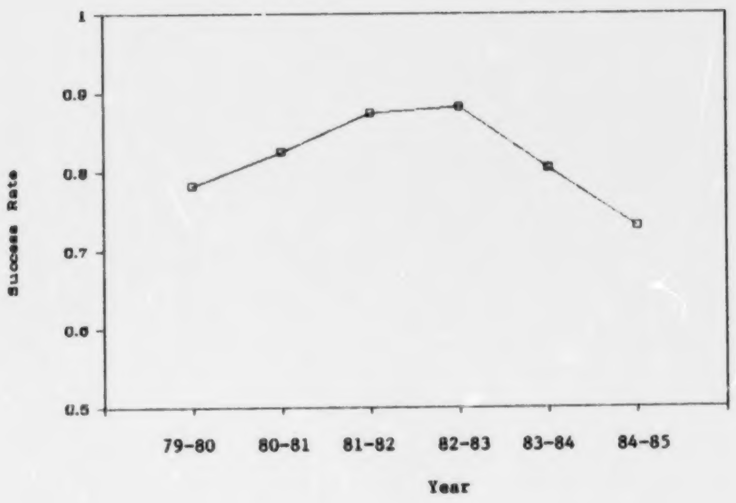
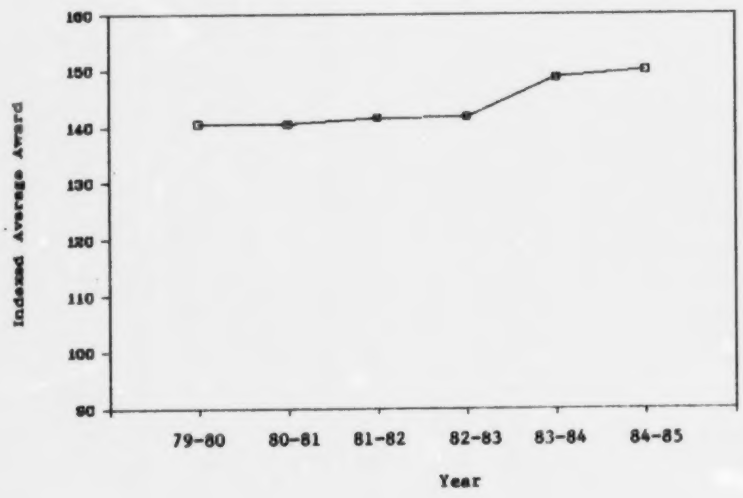
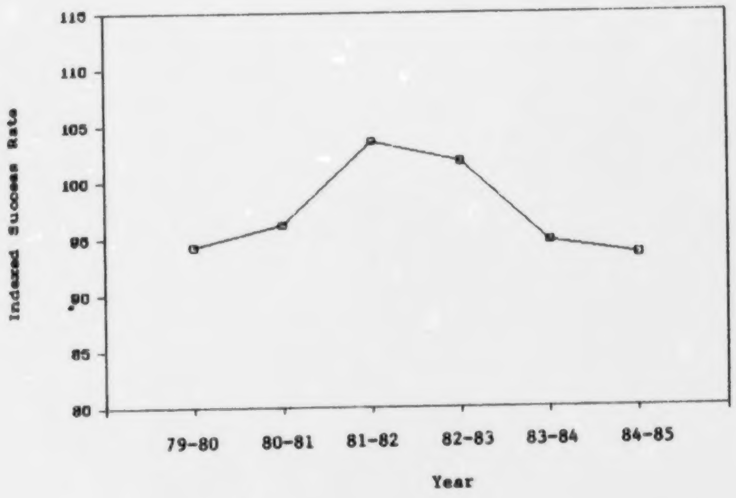
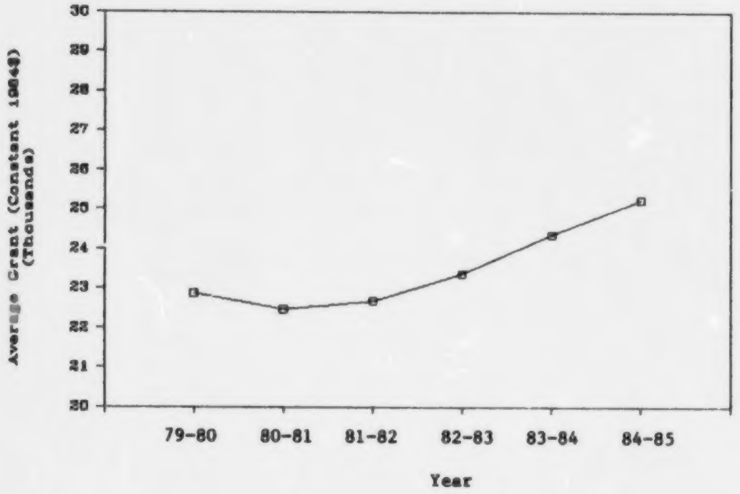


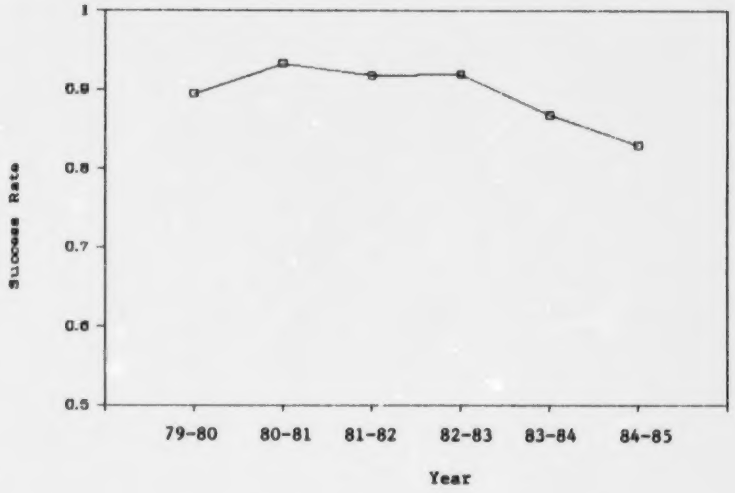


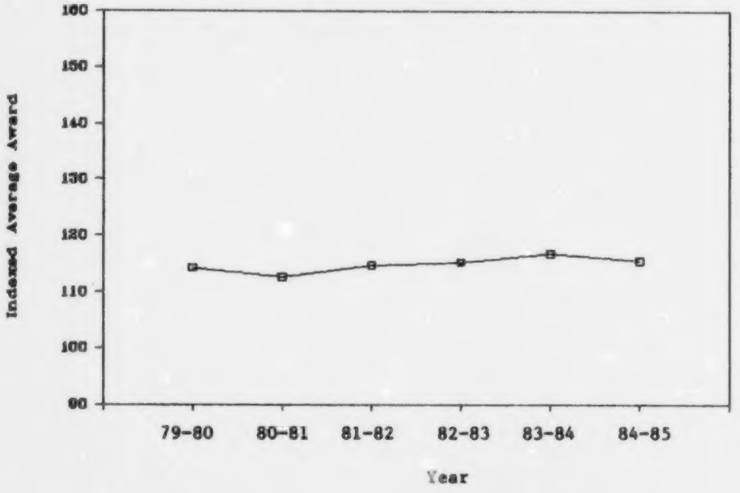


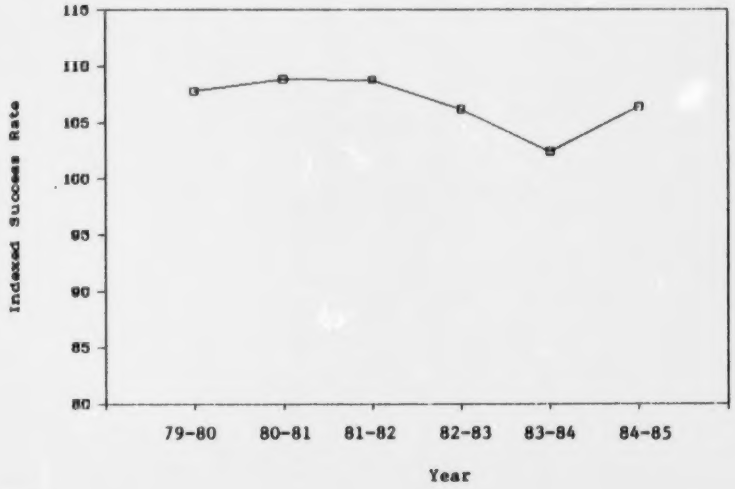


PHYSICS: 1979–1984

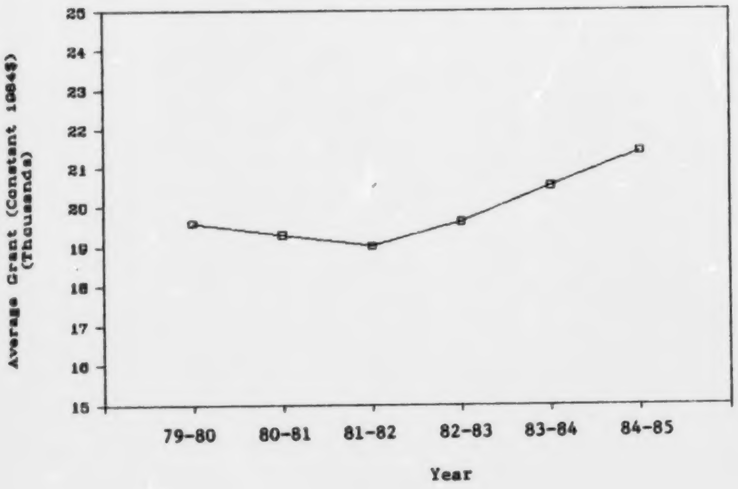


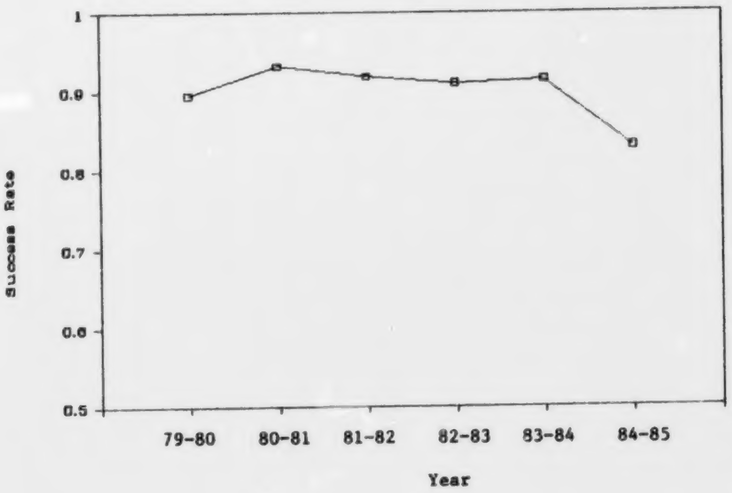


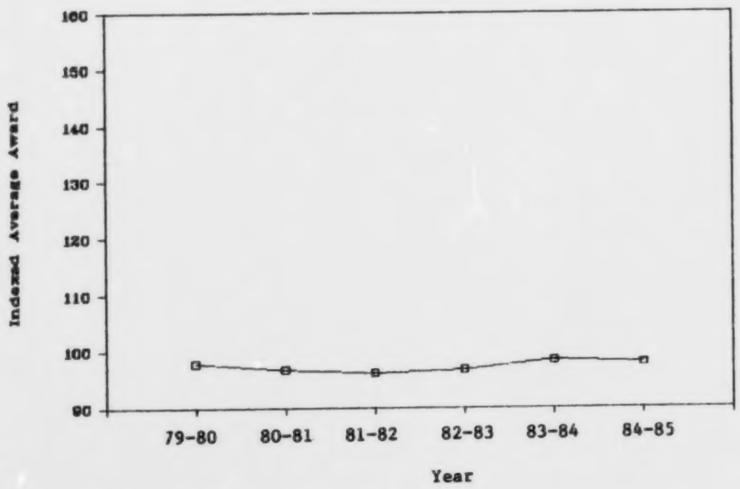


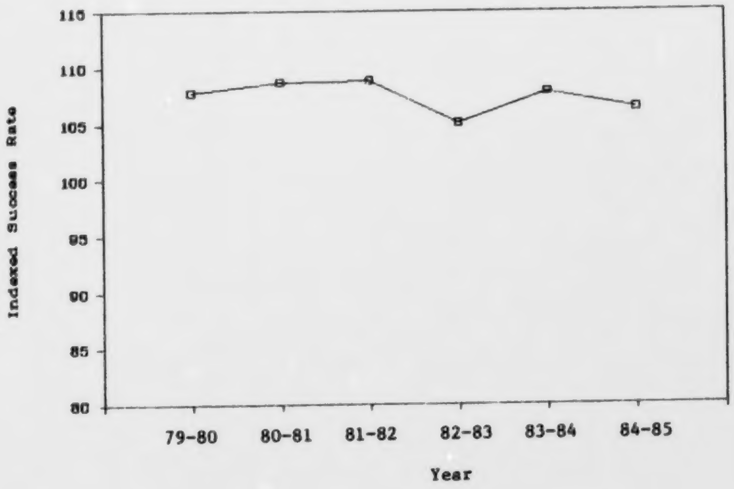


ENGINEERING: 1979−1984

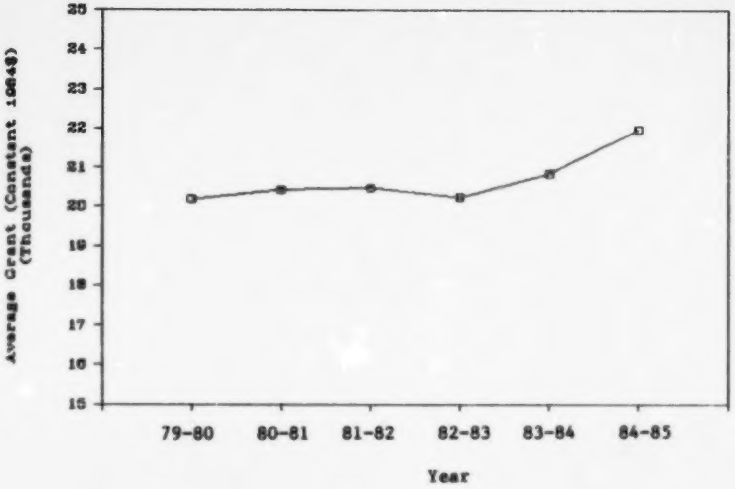


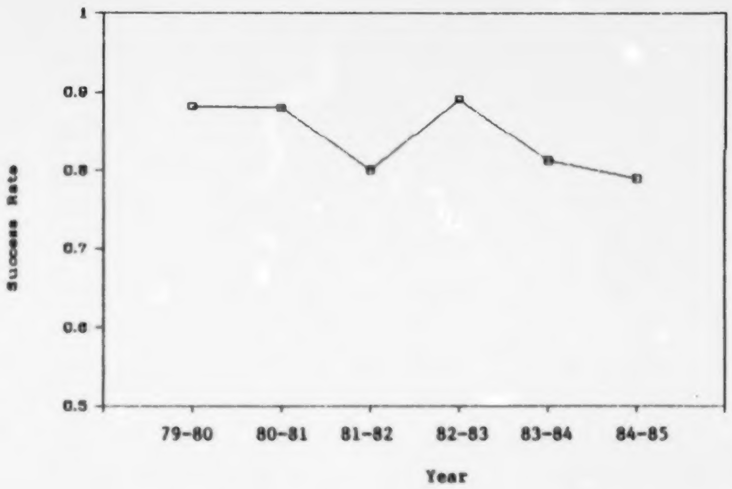


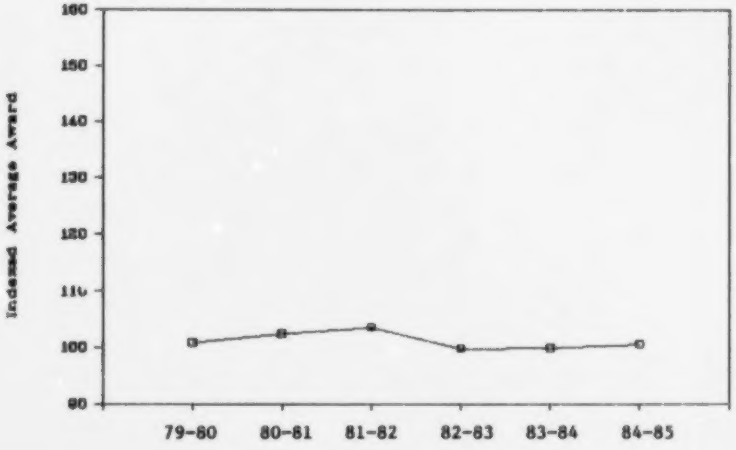


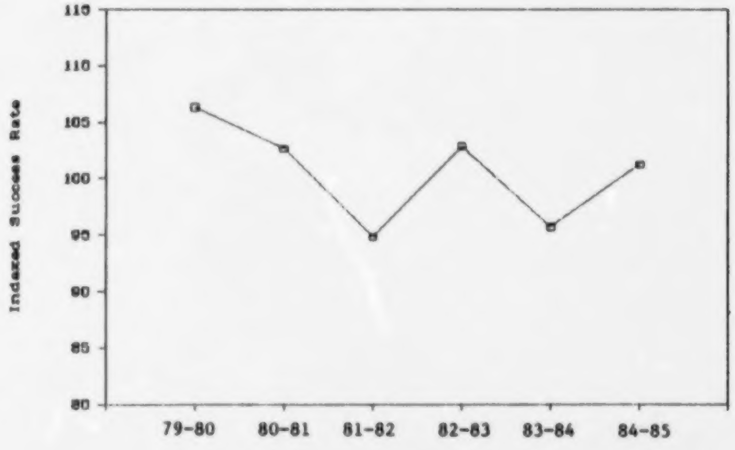


EARTH SCIENCES: 1979–1984

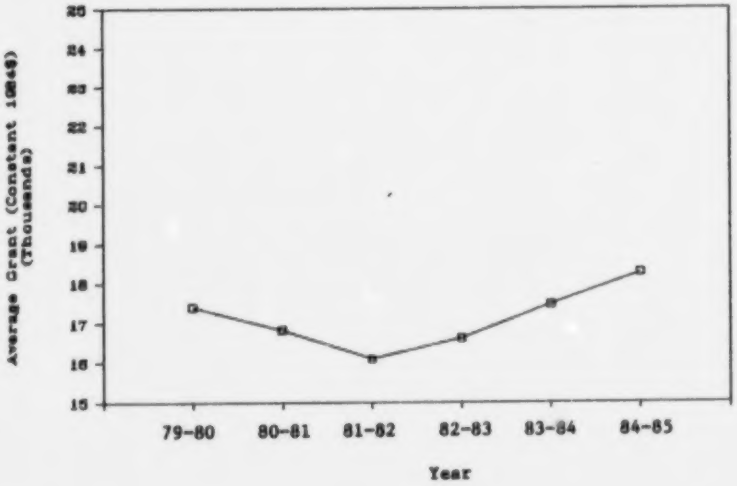


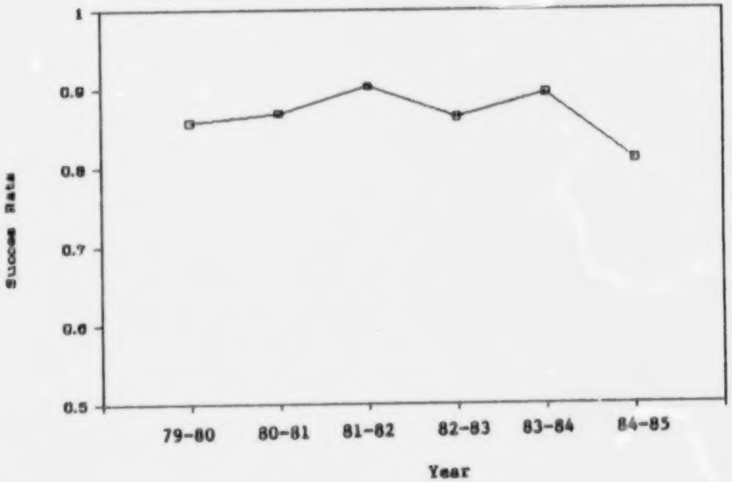


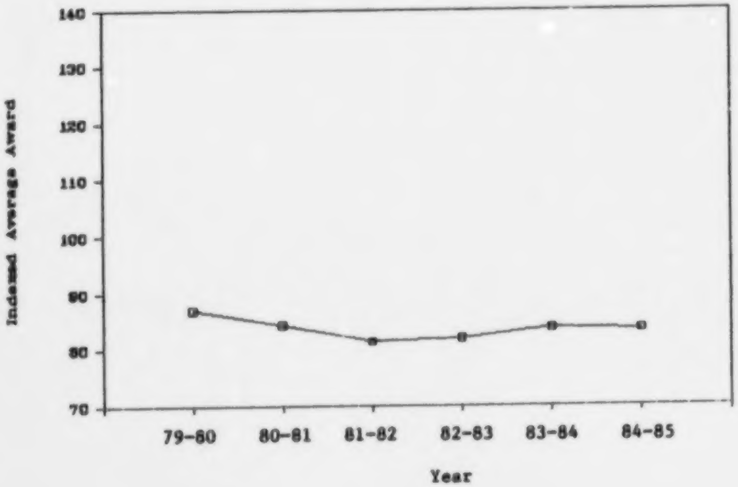


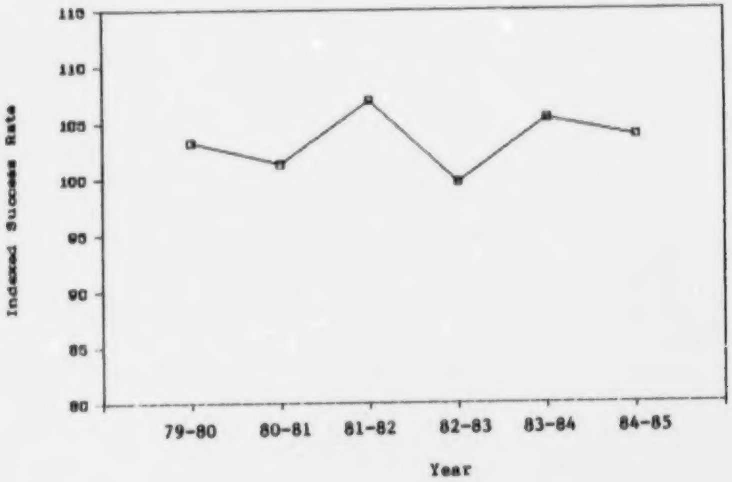


COMP. & INFO. SCIENCES: 1979–1984

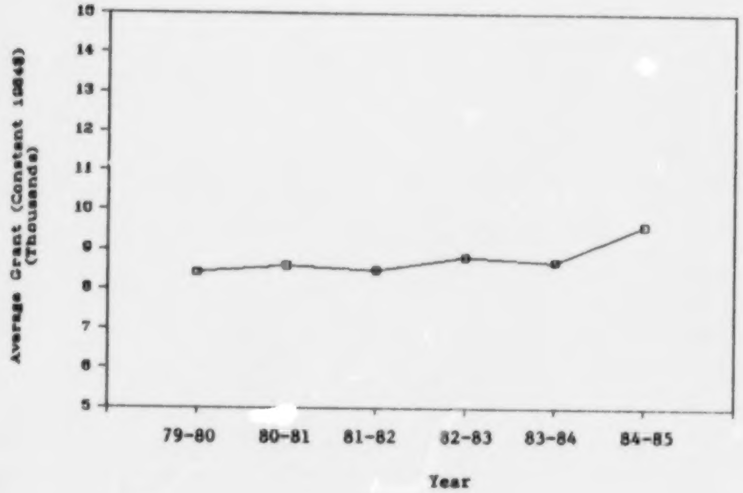


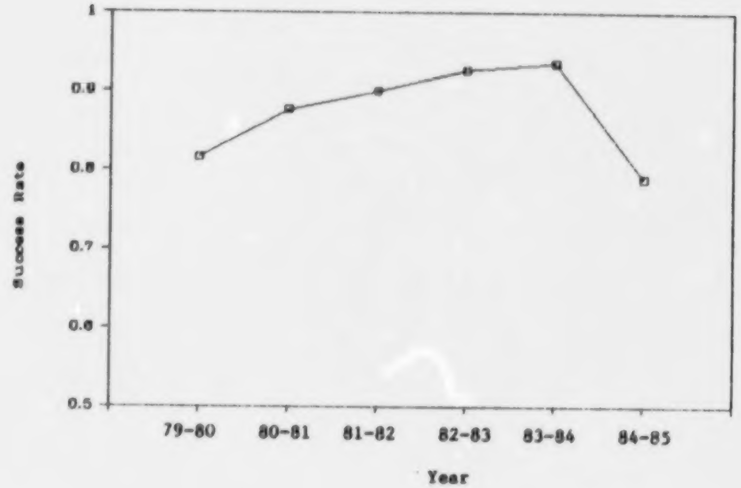


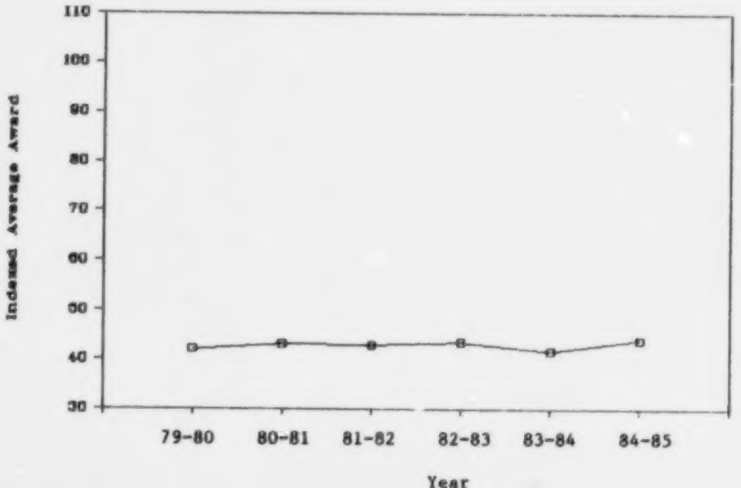


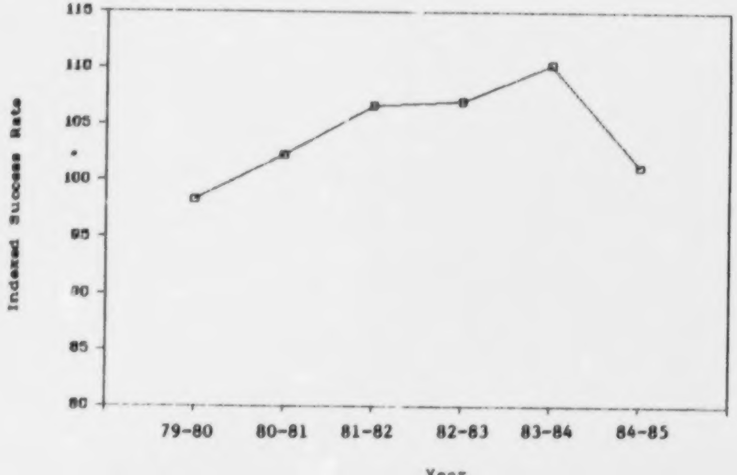


MATHEMATICS / STATISTICS: 1979-1984









The impact of differing selectivity on the average funding level of a discipline is significant, indeed, a small difference in success rate, can lead to a 10-20% difference in average grant level within 5 years with all other factors being equal (rarely the case).

Figure 4 provides an illustration of the trends in average grants as compared with NSERC's average and percentage success rate (competition data) by discipline grouping. Consideration of these data should take into account two major factors which have influenced average funding levels and committee behaviour:

(i) the special allocations of 10% to all engineering GSCs and 20% to computing and information science were phased in from 1982-83 to 1984-85. Special allocations were also made to animal biology (10%), population biology (6.7%), earth sciences (6.7%), mathematics (10%) and statistics (28%).

(ii) some of the funding injected into the Operating Grants Program was constrained in use to "merit supplements" only. Committees were not free to allocate the funding as a straight percentage increase.

Although correlations are tricky to draw without additional information on new entrants and retirements from each community, a decrease in success rate normally produces an increase in average grant within a 2 year period. The decreasing success rates during the three years of the merit supplement scheme should also be noted.

A.7 New Applicants

One of the basic tenets of the operating grants system is that those "starters" or new researchers in the academic research community meeting normal quality standards are given an opportunity to demonstrate their research capability. Indeed, $54.3M (constant 1984-85 dollars) has been spent on new researchers over the period of the first Five-Year Plan. Furthermore, despite initial forecasts of little growth in the research community, NSERC has seen a more-or-less uniform increase in the number of new applicants over time. Table 15 provides an overview of the number of new applicants by discipline grouping and the magnitude of their requests and awards. The discipline distribution of new applicants (Figure 5) does not totally correlate with the net change in the community seen in Figure 2 because of retirements and leavers from the community. The success rates and funding rates of new applicants over the review period are shown in Table 16, with a detailed breakdown of new applicants by grant selection committee in Table 17.

The average grant level for the "starter" grantee varies substantially amongst disciplines, both in terms of its absolute level and its relationship to the average grant for the discipline. NSERC has, however, put significant pressure on discipline selection committees to increase the starter grant relative to the average funding level. Progress in this direction, particularly

TABLE 15

New Applicants*: Selected Data From 1979-80 Onward (Individual and Team Operating Grants Only)
(Current $)

REQUESTS

	1979-80		1980-81		1981-82		1982-83		1983-84		1984-85	
	No.	$000	No.	$000	No.	$000	No.	$000	No.	$000	No.	$000
Biology	83	1459.5	99	1840.5	123	2434.3	89	2128.4	131	3315.9	143	4062.2
Psychology	33	544.7	29	389.5	37	734.7	42	752.6	37	743.3	43	841.6
Chemistry	16	244.8	12	266.4	20	453.6	23	523.3	19	503.3	22	514.9
Physics	18	237.3	20	275.6	14	231.2	20	442.3	24	315.4	26	747.6
Engineering	100	1391.0	100	1340.6	100	1837.6	100	1692.6	157	2883.9	145	2998.6
Earth Sci.	31	374.8	35	589.9	31	452.6	45	780.5	44	936.3	33	694.7
Comp./Info. Sci.	29	289.6	41	486.0	37	494.6	49	804.9	58	970.6	51	1051.7
Mathematical Sci.	51	299.5	21	146.8	34	209.1	32	260.3	47	468.2	48	519.3
Interdisciplinary	0	0.0	4	74.6	14	316.5	11	258.2	10	179.6	12	287.1
TOTAL	361	4841.1	361	5369.9	410	7164.3	411	7643.2	527	10316.4	523	11717.9

AWARDS

	1979-80		1980-81		1981-82		1982-83		1983-84		1984-85	
	No.	$000	No.	$000	No.	$000	No.	$000	No.	$000	No.	$000
Biology	59	652.1	57	582.9	71	774.1	53	784.4	79	1397.7	84	1529.6
Psychology	26	260.3	22	157.0	27	208.0	33	286.0	24	257.6	28	303.9
Chemistry	14	118.8	11	110.0	15	174.0	19	224.5	14	212.0	13	213.8
Physics	13	76.0	18	109.3	14	113.1	18	198.8	13	125.1	19	334.0
Engineering	71	567.4	90	719.9	90	827.9	84	897.0	125	1572.5	104	1593.5
Earth Sci.	25	157.4	33	274.2	21	182.2	38	404.5	33	442.6	22	330.0
Comp./Info. Sci.	21	118.0	32	198.7	31	234.7	37	386.5	45	534.1	38	513.0
Mathematical Sci.	42	137.5	18	31.0	30	63.4	30	97.8	44	189.5	38	268.8
Interdisciplinary	0	0.0	0	0.0	6	70.0	8	92.0	3	31.8	4	64.0
TOTAL	271	2087.5	281	2183.0	305	2647.3	320	3371.6	380	4762.8	350	5150.6

* For this analysis "new applicants" includes both those applicants submitting their first operating grant application to NSERC and applicants who have previously applied to NSERC but have been unsuccessful (the latter category was initiated only in 1982-83).

Figure 5

Distribution of New Applicants and Grantees by Discipline Grouping. Total Number of Entrants Over the Period 1979-80 to 1984-85

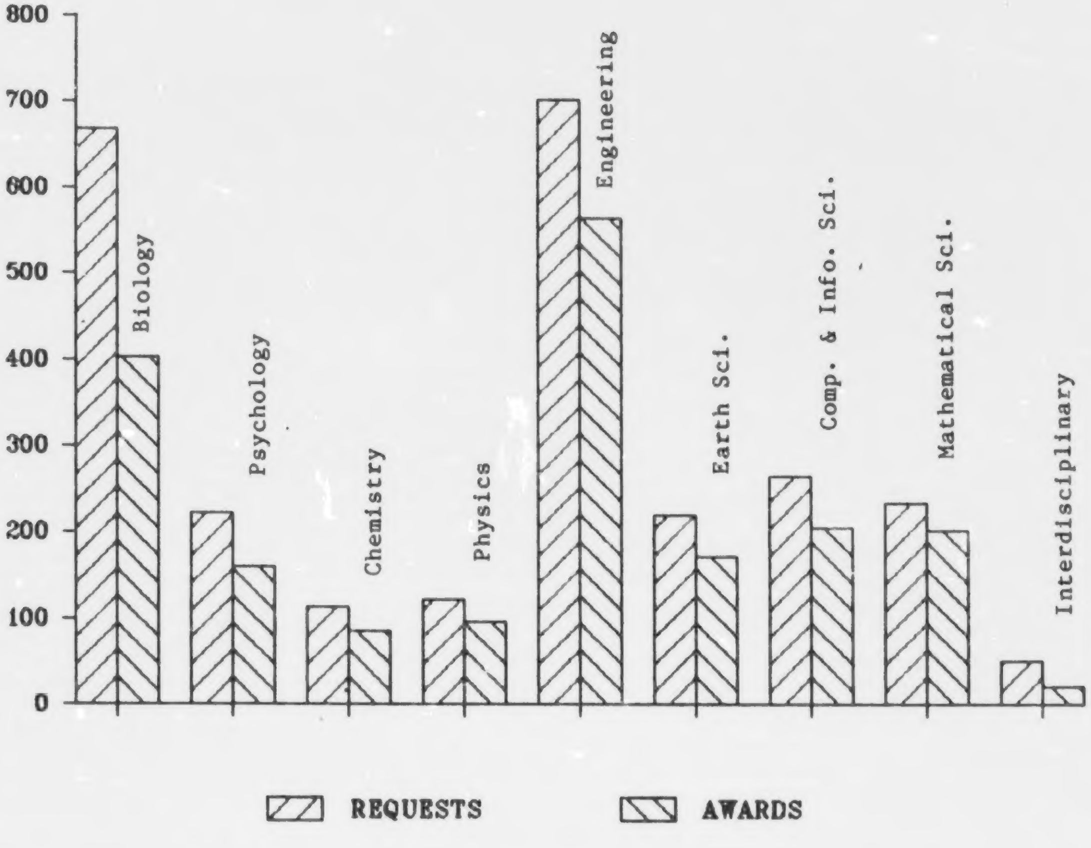


TABLE 16

Success Rates and Funding Rates of New Applicants*

Success Rate (No.)

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-
Biology	0.71	0.58	0.58	0.60	0.60	0.59
Psychology	0.79	0.76	0.73	0.79	0.65	0.65
Chemistry	0.88	0.92	0.75	0.83	0.74	0.59
Physics	0.72	0.90	1.00	0.90	0.54	0.73
Engineering	0.71	0.90	0.90	0.84	0.80	0.72
Earth Sciences	0.81	0.94	0.68	0.84	0.75	0.67
Comp./Info. Sci.	0.72	0.78	0.84	0.76	0.78	0.75
Mathematical Sci.	0.82	0.86	0.88	0.94	0.94	0.79
Interdisciplinary	N/A	0.00	0.43	0.73	0.30	0.33
TOTAL	0.75	0.78	0.74	0.78	0.72	0.67

Funding Rate ($)

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-
Biology	0.45	0.32	0.32	0.37	0.42	0.38
Psychology	0.48	0.40	0.28	0.38	0.35	0.36
Chemistry	0.49	0.49	0.38	0.43	0.42	0.42
Physics	0.32	0.40	0.49	0.45	0.40	0.45
Engineering	0.41	0.54	0.45	0.53	0.55	0.53
Earth Sciences	0.42	0.46	0.40	0.52	0.47	0.48
Comp./Info. Sci.	0.41	0.41	0.47	0.48	0.55	0.49
Mathematical Sci.	0.46	0.21	0.30	0.38	0.40	0.52
Interdisciplinary	N/A	0.00	0.22	0.36	0.18	0.22
TOTAL	0.43	0.41	0.37	0.44	0.46	0.44

* For this analysis "new applicants" includes both those applicants submitting their first operating grant application to NSERC and applicants who have previously applied to NSERC but have been unsuccessful (the latter category was initiated only in 1982-83).

TABLE 17

New Applicants* from 1979-80 to 1984-85

	Number of Requests						Number of Awards					
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Animal Biol.	19	27	44	28	52	45	14	13	23	16	24	26
Cell Biol.	33	22	34	32	30	45	26	15	22	18	22	30
Plant Biol.	9	19	18	9	24	29	8	13	11	7	14	19
Pop. Biol.	22	31	27	20	25	24	11	16	15	12	19	9
Psychology	33	29	37	42	37	43	26	22	27	33	24	28
Chemistry	16	12	20	23	19	22	14	11	15	19	14	13
Physics	14	15	6	10	18	18	9	13	6	9	8	11
Nucl. Sci.	1	0	2	3	1	2	1	0	2	2	0	2
High Ener.	0	0	0	0	0	0	0	0	0	0	0	0
Space/Ast.	3	5	6	7	5	6	3	5	6	7	5	6
Chem./Met.	13	23	21	16	34	24	12	20	21	15	29	18
Civil Eng.	30	32	21	18	31	28	23	28	19	14	26	22
Elec. Eng.	20	21	25	25	41	37	14	20	21	20	36	22
Mech. Eng.	25	16	20	24	27	37	15	14	17	21	19	27
Ind. Eng.	12	8	13	17	24	19	7	8	12	14	15	15
Earth Sci.	31	35	31	45	44	33	25	33	21	38	33	22
Comp./Info.	29	41	37	49	58	51	21	32	31	37	45	38
Mathematics	37	10	21	19	30	26	30	8	20	18	27	18
Statistics	14	11	13	13	17	22	12	10	10	12	17	20
Interdisc.	0	4	14	11	10	12	0	0	6	8	3	4
TOTAL	361	361	410	411	527	523	271	281	305	320	380	350

* For this analysis "new applicants" includes both those applicants submitting their first operating grant application to NSERC but have been unsuccessful (the latter category was initiated only in 1982-83).

for those disciplines that had extremely low starter grants in 1979-80 is shown in Table 18. With the average starter grant now at approximately 67% of the average funding level, NSERC considers that, given existing funding constraints, reasonable opportunities are being offered to new researchers.

A.8 The Established Research Force

Two of the major considerations behind the push for increased selectivity were

(i) the desire to see the senior and fully established researchers provided with higher funding levels to foster truly forefront and internationally competitive research

(ii) the desire to see the most promising researchers provided with better funding earlier on in their careers at the expense of the less productive.

Although these two objectives overlap, different approaches are required to examine the success of NSERC's initiatives in this area.

Table 19 reviews the funding levels of researchers receiving grants in the top 25% of each discipline community as compared with the average funding level for the same community. The ratio of the funding levels for the top 25% to the "average" has decreased from 1.90 to 1.87 over six years; over this time, however, there has been a change in the average grant size of - 6.6% and 9.2% for "top" grantees and all grantees respectively (current 1984 $). The reader is cautioned that similar caveats pertain to this analysis of average grant data as were described in Section A.6 on selectivity.

Table 20 presents an analysis of the change in the population of researchers with grants in the top 10% (by $) of each discipline over the period 1979-80 to 1984-85. On average in excess of one third of the top 10% in the 1984-85 community had moved up from the "ranks" below during the preceding five years.

The extent to which established researchers were awarded decreases in funding is shown in Table 21. In this analysis, the community of applicants for individual operating grants (by competition) was divided into quartiles on the basis of their funding level at the time of application for a grant renewal. The number of applicants receiving decreased funding by quartile was then tabulated. As expected, the majority of individuals who were awarded decreases were in the lowest quartile; however, the data demonstrate a significant number of funding decreases for recipients of large grants in some discipline areas. Mathematics and Population Biology stand out as having a fairly high percentage of the well funded grantees being awarded decreased funding.

The question now facing NSERC and many of the discipline committees is whether further differentiation of the funding levels for the well established researchers from the average or starter grant levels is in the best interests of the health of the academic R & D community. Many outstanding researchers have relatively low cost research programs; other more juniour researchers are embarking on research activities that are very costly. Regardless, there will be continued scrutiny of funding patterns and selectivity.

TABLE 18

Comparison of Average and Starter Grant Levels by Discipline 1979-80 and 1984-85

	1979-80			1984-85		
	Starter	Average	% (St/Av)	Starter	Average	% (St/Av
Animal Biology	6.8	13.9	49	16.5	24.0	69
Cell Biology	12.9	16.7	77	20.8	28.9	72
Plant Biology	12.6	15.9	79	16.3	26.5	62
Population Biology	11.1	12.5	89	18.6	23.3	80
Psychology	10.0	12.2	82	10.9	18.4	59
Chemistry	8.5	18.0	47	16.4	32.8	50
Physics	4.3	14.1	30	13.0	24.8	52
Space & Astronomy	7.7	14.7	52	14.3	24.0	60
Chem./Met. Eng.	7.6	13.5	56	16.7	24.2	69
Civil Eng.	8.6	12.3	70	16.2	21.4	76
Electrical Eng.	8.0	12.3	65	15.9	20.6	77
Mechanical Eng.	8.5	12.7	67	15.6	21.5	73
Industrial Eng.	5.5	9.6	57	11.0	15.9	69
Earth Sciences	6.3	12.9	49	15.0	22.0	68
Comp. & Info. Sci.	5.6	11.1	50	13.5	18.3	74
Mathematical Sci.	3.5	5.4	65	8.4	10.0	84
Statistics	2.7	5.5	49	5.8	8.6	67
NSERC	7.7	12.8	60	14.7	21.9	67

TABLE 19

Individual Operating Grants
Average Grants (i) all Grantees and (ii) the Top 25% of Grantees (current dollars)

Grant Selection Committee	Portion of Grantees	Year 79-80	80-81	81-82	82-83	83-84	84-85
Animal Biol.	Top	26,045	29,632	33,361	39,383	41,375	44,592
	All	13,911	15,539	17,624	20,749	21,455	23,961
Cell Biol.	Top	29,991	32,746	36,570	42,111	46,618	50,949
	All	16,716	18,545	20,832	24,282	26,685	28,941
Plant Biol.	Top	30,476	34,493	36,581	44,057	48,676	51,111
	All	15,892	17,823	19,018	22,613	24,587	26,497
Pop. Biol.	Top	23,051	28,130	31,617	36,705	41,090	44,408
	All	12,534	15,031	16,713	19,665	21,954	23,346
Psychology	Top	25,090	27,820	29,443	32,108	34,537	38,069
	All	12,220	13,168	13,928	15,530	16,730	18,371
Chemistry	Top	35,907	39,148	43,207	48,820	54,754	59,983
	All	18,000	20,031	22,319	25,828	29,550	32,799
Physics	Top	27,388	29,638	33,305	39,432	43,479	46,973
	All	14,091	15,128	17,269	20,225	22,597	24,808
Nucl. Sci.	Top	37,429	48,667	51,191	57,432	68,398	63,156
	All	18,246	24,217	26,401	29,129	35,446	34,021
Space/Astronomy	Top	30,283	32,661	35,244	42,089	45,278	50,093
	All	14,714	15,929	17,789	20,653	21,500	23,963
Chem./Met Eng.	Top	24,656	26,328	28,788	33,890	37,933	42,331
	All	13,497	14,692	16,225	19,095	21,076	24,161
Civil Eng.	Top	20,996	22,268	24,326	27,979	33,792	37,170
	All	12,328	13,249	14,342	16,864	19,383	21,376
Elec. Eng.	Top	22,833	24,710	27,402	32,374	34,873	37,645
	All	12,326	13,662	14,915	17,233	18,878	20,568
Mech. Eng.	Top	21,833	23,938	26,283	30,654	34,404	36,200
	All	12,692	14,086	15,493	18,171	20,302	21,540
Industrial Eng.	Top	18,521	21,992	24,557	28,391	29,539	31,093
	All	9,658	11,065	13,341	14,447	15,134	15,924
Earth Sci.	Top	24,044	27,047	30,174	33,218	36,478	40,945
	All	12,913	14,594	16,323	18,180	19,844	21,987
Comp./Info. Sci.	Top	20,882	22,300	24,104	28,465	31,625	34,320
	All	11,128	12,016	12,829	14,929	16,639	18,264
Mathematics	Top	12,751	14,715	16,318	19,126	19,652	22,320
	All	5,372	6,217	7,015	8,281	8,404	9,964
Statistics	Top	13,516	14,770	14,578	15,642	17,322	18,143
	All	5,539	5,778	5,956	6,781	7,871	8,642
Interdisc.	Top	17,500	23,954	27,310	30,605	33,030	35,546
	All	12,770	14,716	15,165	16,349	17,787	20,240
TOTAL	Top	24,498	27,149	29,862	34,377	37,535	40,849
	All	12,801	14,249	15,759	16,217	19,863	21,857

TABLE 20

Changes in Composition of The Top 10% in Each Discipline 1979-80 to 1984-85

	Top 10% (No.)	New Entrants to Top 10% (No.)	% Change*
Animal Biol.	37	16	43
Cell Biol.	36	15	42
Plant Biol.	25	12	48
Population Biol.	34	20	59
Psychology	34	7	21
Chemistry	49	18	37
Physics	39	13	33
Nuclear Sci.			
Space/Astronomy	13	6	46
Chem./Met. Eng.	34	14	41
Civil Eng.	36	10	28
Elec. Eng.	38	12	32
Mechanical Eng.	32	11	34
Industrial Eng.	11	4	36
Earth Sci.	48	16	33
Comp./Info. Sci.	34	13	38
Mathematics	55	11	20
Statistics	20	8	40
TOTAL	575	206	36

* With 1984-85 as reference year.

TABLE 21

No. Applicants Receiving Decreased or Nil Funding - by Quartile[1]

Grant Selection Committee	Top 25%				2nd 25%				3rd 25%				4th 25%				No. Applicants			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
Animal Biology	5	3	7	0	8	11	10	1	7	6	10	5	10	5	13	6	103	123	88	113
Cell Biology	3	6	0	3	2	7	3	7	5	6	3	8	8	12	15	10	98	133	107	99
Plant Biology	4	3	2	7	5	2	5	10	5	6	5	6	7	8	9	8	71	72	76	81
Population Biology	7	4	4	6	5	8	9	4	7	7	9	6	12	6	27	13	92	113	135	121
Psychology	2	3	1	2	5	4	3	5	4	3	3	10	6	5	14	14	80	86	72	97
Chemistry	12	11	6	7	13	11	9	9	9	4	9	12	17	17	27	25	257	247	242	198
Physics	5	2	2	9	4	1	5	10	9	2	5	8	6	9	16	15	165	139	156	143
Space/Astronomy	2	0	1	0	1	2	2	1	1	0	2	0	2	1	9	6	49	42	54	46
Chem./Met. Eng.	6	1	1	0	6	1	2	1	3	2	2	2	9	2	4	12	106	65	127	122
Civil Eng.	3	2	1	3	3	1	2	0	5	2	2	6	4	5	7	7	73	96	106	85
Elec. Eng.	12	5	11	7	10	5	2	5	8	7	2	4	10	6	12	11	167	146	210	137
Mech. Eng.	2	4	0	2	3	5	3	5	3	2	13	3	2	10	12	6	84	102	114	77
Ind. Eng.	1	3	1	1	1	0	3	0	3	3	3	1	3	1	5	1	25	29	41	26
Earth Sciences	12	7	1	7	9	3	5	17	11	3	5	13	15	10	24	24	233	234	177	198
Comp./Info Sci.	5	1	1	11	5	4	6	15	6	12	6	13	7	19	23	29	151	167	172	178
Mathematics	12	9	8	11	12	12	8	7	11	11	8	12	12	5	11	18	180	158	151	179
Statistics	2	9	2	2	0	2	2	2	0	3	2	1	0	3	4	2	7	59	48	48

(1) Quartiles based on grant levels held by applicants as they entered the competition.

B. OPERATING GRANTS - PROJECT

B.1 Program Objectives

Project Grants are intended to foster excellent research in subatomic physics* requiring the use of specialized facilities located in Canada (TRIUMF) and abroad. As in the case of individual and team operating grants, these grants also play a major role in the training of graduate students.

B.2 Program Characteristics

Research involving major facilities in subatomic physics differs from that conducted under individual and team operating grants in magnitude and scheduling. Each experiment is a major undertaking by a group of investigators that has to be carried out on an agreed schedule. It is, in fact, a project requiring firm commitments from all the investigators who cannot have the freedom to decide independently how their "share" of the project grant should be spent.

At the present time, project operating grants are restricted to subatomic physics. However, other areas of science are moving, at least in part, towards this mode of operation (e.g. space physics) and consideration will be given to the most appropriate funding mechanisms of support in future, including the possibility of extending project grants into these areas.

In subatomic physics, experiments at TRIUMF and large accelerators outside Canada require a significant period of planning and in the latter case, the Canadian experimenters will generally be a sub-group of a large international collaboration. Putting together a proposal for an experiment involves considerable negotiations. All large facilities including TRIUMF have an experiments evaluation committee and an operating committee. These committees have the responsibility to, respectively, approve the proposals and allocate scheduled beam time. Only then can the granting agencies be approached for specified funding requirements. Experiments normally have a threshold requirement for funding of manpower and equipment; hence many project grants incorporate the equipment necessary to pursue the stated project objectives, rather than providing support separately through equipment grants. Funding requirements for a project can also fluctuate significantly from year to year, hence annual reviews of progress and financial need are carried out. There are, at present, no multi-year project grants.

Three other features of the system are also important - (i) a researcher would generally be engaged in more than one project at any given time, although the graduate students would normally be associated with only one;

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*Subatomic Physics includes low energy nuclear physics (normally carried out at local nuclear facilities in Canada), intermediate energy physics (normally experiments at TRIUMF) and high energy physics (experiments done at foreign accelerators).

(ii) a researcher receiving support from one or more project grants may receive an operating grant for work that is not associated with a major specialized facility, (iii) special mechanisms are required to cope with the problems of fluctuations in financial requirements and continuity of technical support staff. These mechanisms are as folows:

- 20-30% of a project grant in high energy physics is normally paid directly to the Institute of Particle Physics (IPP) instead of the investigator. IPP then has the flexibility to "smooth out" fluctuations in financial requirements amongst projects that are caused by scheduling problems.
- For work in intermediate physics energy, core support of TRIUMF through the NRC contribution provides a stabilizing influence. Furthermore, the Director of TRIUMF has, at his disposal, some resources that can be used for major problem areas.
- For intermediate energy physics, a system of "core salary grants" provides technical and professional assistants with some assurance of continuing employment. Although the original intent was that there would be only one such grant for each university, there has been some fragmentation (there are now two at several universities) which must be re-examined by NSERC and the selection committee.

To properly assess the funding and success rates in the intermediate energy physics area, "core salary" support must be tabulated as a separate line item.

B.3 Overview of Program Support

Although all support for subatomic physics is now reviewed by a single grant selection committee, at the beginning of this period it was split into three component parts reviewed by three separate selection committees - nuclear physics (low energy), intermediate energy physics and high energy physics. Project grants have been in force for intermediate energy physics and high energy physics only, and these two committees were amalgamated in 1985.

Table 1 provides an overview of requests and awards in project grants over the period 1979-80 to 1984-85. Because of the great differences between project grants in intermediate and high energy physics, these are reported separately. As requests for both renewals and initiation of new projects are considered each year, these data do not reveal the level of competition for initiation of new projects. An analysis of competition results is given in Table 2 (note - "new project" is a term that is difficult to define and hence these data should be considered as approximate only).

While projects in intermediate energy physics have a time horizon of about five years, those in high energy physics have a "horizon" of about ten years for planning and execution of the project. This naturally excludes the planning and construction of the facility, but does include the major detectors that form part of a high energy experiment. This scale of operations brings

TABLE 1(A)
Project Grant Support in Intermediate Energy Physics

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Number of Projects*						
Requested	37	39	40	38	39	44
Awarded	34	36	35	35	32	34
Success Rate (%)	92	92	88	92	82	77
Project Support ($000)						
Requested	2767	3222	2491	2678	2762	4338
Awarded	1656	1782	1408	1645	1714	2027
Funding Rate (%)	60	55	57	61	62	47
No. of Core Salary Grants**						
Requested			8	9	9	10
Awarded			8	9	9	10
Success Rate (%)			100	100	100	100
Core Salary Support ($000)						
Requested			1149	1326	1561	1867
Awarded			758	1085	1221	1485
Funding Rate (%)			66	82	78	80

* For the purpose of this analysis, projects for which awards are split between more than one location are considered as one project only; hence the data differ from those reported for financial purposes.

** In addition to the core salary support, over the period 1980-81 to 1982-83 special research scientist grants were awarded to four university groups in the following amounts

1980-81	$156k
1981-82	$201.6k
1982-83	$196.5k

These grants were discontinued thereafter.

TABLE 1(B)
Project Grant Support in High Energy Physics

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Number of Projects						
Requested	11	8	7	10	11	10
Awarded	10	8	5	10	8	9
Success Rate (%)	91	100	71	100	73	90
Project Support ($000)						
Requested	2224	2180	2176	4027	4015	4210
Awarded	1367	1541	1687	2383	2527	2510
Funding Rate (%)	61	71	78	59	63	60
IPP Activities ($000)*						
Requested	182	232	327	422	452	560
Awarded	100	201	302	344	313	395
Funding Rate (%)	55	87	92	82	69	71

* These data do not include funding awarded for special major projects:

1980-81	$220k (CHEER)
1981-82	$225k (CHEER)
1983-84	$1,100k (HERA)

TABLE 2
New Applications for Project Grants

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Intermediate Energy Physics - Number of Applications						
Requested	11	6	10	11	13	20
Awarded	9	5	5	9	8	11
Success Rate (%)	82	83	50	82	62	55
Intermediate Energy Physics* - Support ($000)						
Requested	734	239	429	484	915	1845
Awarded	242	132	109	334	278	401
Funding Rate (%)	33	55	25	69	30	22
High Energy Physics - Number of Applications						
Requested	2	0	2	5	2	3
Awarded	1	0	0	5	0	2
Success Rate (%)	50	-	0	100	0	67
High Energy Physics - Support ($000)						
Requested	392	0	226	1899	536	896
Awarded	148	0	0	945	0	480
Funding Rate (%)	38	-	0	50	0	54

* In addition to the new projects there were applications for new core salary grants which were not reported in this analysis.

with it particular problems in that long-term planning of the most effective use of financial and human resources must be carried out in the absence of any firm projections of the availability of either resources.

Over the last few years there have been changes in research interest and therefore the distribution of financial resources within the subatomic physics community. In part this has been brought about by the phasing out of NSERC support for local nuclear physics facilities which have now become less competitive, in order to free up resources for new research challenges. Overall there has been increasing interest in work at higher energies.

C. E.W.R. STEACIE MEMORIAL FELLOWSHIP PROGRAM

C.1 Program Objectives

Steacie Fellowships, Council's most prestigous awards are intended to recognize the achievements of a limited number of outstanding young scientists and engineers in Canadian universities and to enhance their research opportunities.

C.2 Program Characteristics

Through this program, NSERC provides complete salary support for the successful Fellow for up to 2 years and offers them the opportunity to request additional grant support during the tenure of the Fellowships. The award enables Fellows to devote all their time and energy to their research programs at an important and productive period of their career and provides NSERC an opportunity to recognize outstanding research success.

C.3 Profile of Steacie Fellows

Competition for the Fellowship is extremely severe. Candidates may not apply on their own initiative, but must be nominated by their department or senior members of the Canadian science and engineering community, with the endorsement of the executive head of the candidate's university. Normally there are over 40 candidates for these Fellowships; the number of awards is strictly limited to 4 - a success rate of at best 10% even with this "pre-selection".

The evaluation of candidates is rigorous, using a combination of written reports from external referees and a multidisciplinary review committee. The selection criteria focus on demonstrated research excellence of the highest quality, with clear potential for continued development and benefit from the award of a Fellowship. There are no quotas by discipline or region, but an after the fact analysis provides an interesting overview of the areas of strength observed through this program. Tables 1 and 2 below give an overview.

TABLE 1

Distribution of Steacie Fellowships by Discipline Grouping for 1979-80 to 1984-85

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	Total
Biology	1	1	1	2	1	1	7
Psychology	2						2
Chemistry		2		1	1		4
Physics						1	1
Engineering	1	1	2		1	2	7
Earth Sciences			1		1		2
Comp. & Info. Sci.							0
Mathematical Sci.				1			1

TABLE 2

Distribution by Region of Steacie Fellowships 1979-80 to 1984-85

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	Total
East	1	-	1	-	1	-	3
Quebec	1	-	2	1	-	1	5
Ontario	-	2	1	3	3	1	10
West	2	2	-	-	-	2	6

C.4 Performance in Operating Grants

Receipt of a Steacie Fellowship is expected to provide opportunities for enhancement of a research program and its success in so doing can be assessed by examining the operating grant history of the recipients. Although the number of recipients is low, the following data demonstrate that this group of researchers has received strong endorsement from the peer-review system for their level of productivity and the significance of their contributions.

TABLE 3

Operating Grant Status of Recipients of the E.W.R. Steacie Memorial Fellowship

Sample size	16
Status one year prior to award of Fellowship	
- average grant (1984 $)	$39,143
- ratio of average grant to discipline average of the year	1.84
Status three years after award of Fellowship	
- average grant (1984 $)	$58,722
- ratio of average grant to discipline average of the year	2.49

APPENDIX IV

TARGETED RESEARCH

SECTION A

Strategic Grants Program

This section provides information on the program from 1979 to 1985.

A-1 Requests - Awards per Selection Area

Tables IV-1 to IV-9 give the numbers of applications and awards, the success rates and the mix of awards for the period 1980-1985 for the program as a whole and, subsequently, for each of the selected areas.

A-2 Analysis of Grantees

Table IV-10 relates to the level of operating grants of holders of strategic grants.

A-3 Committee Membership

Table IV-11 provides details on members of the strategic grants panels for 1984-85.

A-4 Success Stories

Power lines or highrise buildings constructed near AM broadcast transmitting antennas can intercept part of the radiated signal and re-radiate it in undesired directions. An effective device in combatting this problem was developed by Dr. K.G. Balmain and his graduate students at the University of Toronto. Dr. Balmain adapted modern computational techniques for use by the broadcast industry in analyzing re-radiation problems. As well, he devised 'detuners' for both power lines and highrise buildings which redirect the radiated signals. Elder Engineering Ltd., a broadcast consulting company, was involved with the field measurements, and the cooperation of Ontario Hydro made possible full-scale tests on power lines.

A Simon Fraser University research team, led by Dr. John H. Borden, successfully isolated, identified and synthesized pheromones (a class of behaviour-modifying hormones) for use against the Mountain Pine Beetle. These substances have proved effective in containing or concentrating infestations and mopping up residual populations after logging operations. Dr. Borden's team also developed a method to synthesize the pheromone lineatin, responsible for aggregation behaviour in the Striped Ambrosia

Beetle, a pest which costs the British Columbia lumber business millions of dollars annually. This synthesizing process is used commercially by Phero Tech Inc. of Vancouver (a young, innovative company specializing in behaviour modifying chemicals) to produce a pheromone for Ambrosia Beetle management in British Columbia, Washington State and Alaska and is being considered for use in Europe by Celamerck GmbH, West Germany.

A project to improve crop productivity in the cool, short growing seasons of the Canadian Prairies resulted in the development of a complete management system for winter wheat production which has been adopted into the Manitoba Crop Production recommendations. The research team, led by Dr. W. Bushuk, University of Manitoba, also developed several corn cultivar lines that have greater tolerance to cool temperatures during early growth stages and shorter maturing periods. The new cultivars should gradually expand the corn growing area west and north.

As a result of an NSERC strategic grant in 1981, Professor C.K. Campbell of McMaster University has improved the precision of surface acoustic wave resonators to the point where they can seriously be considered for mobile radio communications. A Canadian company, RMS Industrial Controls, has incorporated the results of this research into a new product line of UHF mobile radios.

The average homeowner is becoming increasingly aware of energy conservation but frequently is unsure of how to make the most efficient use of his conservation dollar. Using computer simulations, a research team headed by Dr. William Colborne at the University of Windsor has identified the most efficient retrofit strategy for energy conservation in single family homes. The results of his research have been widely publicized and a number of seminars have been held for practising engineers and experts in the insulation business. Dr. Colborne's research was aimed at enabling policy makers to make better use of energy-saving incentives. It was carried out using data for the Windsor area, but since then the Toronto, Ottawa and Winnipeg regions have been studied. Weather data are now being compiled to establish the same information for other areas in Canada.

It is now possible to predict outbreaks of army worms, a sporadic pest of cereal and forage crops. Dr. J.N. McNeil of Laval University studied the role of the behaviour-modifying pheromones of the insect and the results of his research have been incorporated into Agriculture Quebec's monitoring system. As a direct result, Quebec farmers were given a two-week warning of the 1984 outbreak, thereby minimizing crop losses.

A research project led by Dr. David Piper, formerly of Dalhousie University, has provided valuable scientific background for offshore hydrocarbon exploitation. Predictive models of glacial history and sedimentation are important in interpreting site specific surveys of offshore wells. Industry uses this information to evaluate possible sites for drilling operations.

Should a harmful substance accidentally be introduced into the Fraser River, it is now possible to predict its distribution in the central Strait of Georgia knowing only the wind and river discharge rates, thanks to the results of a research project begun in 1979 by Dr. G.S. Pond and Dr. W.J. Emery of the University of British Columbia. The numerical results of this research, combined with the tidal models of another study, permit the prediction of flow trajectories for oil and other effluents. They can also be used to find survivors of marine accidents, a situation in which time is critical.

Dr. M.R. Samoiloff of the University of Manitoba has developed and tested methods of using laboratory stocks of worms as simple indicators of toxic effects in contaminated water, air and soil systems. The tests examine survival, development, and genetic effects of single chemicals and mixtures of chemicals contained in environmental samples. Requiring only 96 hours to complete, the tests are both sensitive and cost-effective. The use of the test permits the rapid determination of the toxic potential of air, water or tissue samples taken from a contaminated indoor or outdoor environment. A Winnipeg company, Bioquest International Inc., is performing the tests commercially for several government and corporate clients.

Dr. J.D. Shorthouse of Laurentian University developed the world's first facility for growing food plants underground in a working mine. The Inco Ltd. mine was chosen because it was already equipped with ventilation, hoisting and pumping services. Light was provided by high-intensity 'grow' lamps. Although the yields are below that of greenhouse grown crops, the techniques established should allow northern mines to provide fresh vegetables during mid-winter for local consumption.

As a result of research comparing the quality of deciduous tree pulp from aspen and birch to that of coniferous pulp from fir, pine and spruce, Dr. J.L. Valade and colleagues from the Université du Québec à Trois-Rivières have shown that up to 30% deciduous tree pulp can be incorporated into coniferous pulps to produce newsprint of equivalent quality to that produced exclusively from coniferous pulp. This finding can lead to significant savings for paper manufacturers by encouraging more effective use of those species of woods with a lower commercial value. Industrial trials are now being conducted with paper manufacturers to determine the viability of this new approach.

Dr. D.P.S. Verma of McGill University succeeded in identifying several of the plant and bacteria genes involved in nitrogen fixation and is attempting to transfer this ability to other plants. This would eliminate the need for costly nitrogen fertilizer. The study which has provided valuable insight into the nitrogen fixation process, has been useful in developing new inoculum to enhance legume crops. The development of new strains of inocula is being further pursued by a Canadian biotechnology company, Allelix Inc. of Toronto, for eventual marketing.

With the aid of a 1981 strategic grant, Dr. Saul Wolfe, Queen's University, and his colleagues, Drs. Susan Jensen and Donald Westlake of the University of Alberta, developed a technically simpler and potentially more economical route to new antibiotics. To date, several have been produced and are now undergoing further studies by pharmaceutical companies. Dr. Wolfe has been in close contact with pharmaceutical laboratories in Canada, the United States, Japan and Europe since the beginning of his research program.

SECTION B

University-Industry Program

B-1 Five-Year Commitments

Table IV-12 represents the NSERC and industrial commitments for each of the program element over the period of 1984-85 through 1989-90.

B-2 PRAI Grant Program Evaluation Summary

In 1983, the PRAI grant program was evaluated.

B-2.1 Evaluation Study

The Abt Associates study was based on a review of NSERC records and publications, interviews with NSERC and NRC staff, telephone surveys of NSERC grantees, firms and university administrators. In addition, 28 projects that received PRAI funding during 1975 to 1982 were selected for detailed case studies. These studies involved telephone interviews with the grantee, the collaborating company and the liaison officer; site visits were also used in order to gain a deeper understanding of individual projects and their impacts.

B-2.2 Study Findings

The consultants judged 22 of the 28 projects studied to be successful. The six unsuccessful projects were either terminated by NSERC (work being done elsewhere) or did not advance to a stage where the product could become marketable. Among the 22 successful projects are: the development of an improved structure for grain storage, a rapid test for the evaluation of bacteriological quality of boxed beef, the development of high intensity light guides and improvement in the quality of mechanical pulp from grindstone. In the consultant's opinion, 15 of the 28 projects would not have been conducted without PRAI funding while a further 10 projects were conducted sooner or in an altered form.

The projects have resulted in social and economic benefits to participants and others:

- Collaborating firms benefit from new or altered products, processes, costs saving techniques or innovations. The results from 10 of the projects have already been commercialized. A further six will likely be marketed in the future.

- Many of the university researchers have reoriented their research and teaching toward industry needs and application.

- Research assistants and graduate students have gained industry-related work experience. Indeed, for one-quarter of the projects, at least one assistant or student obtained employment as a direct result of working on the project.

- University researchers and/or collaborating firms have been encouraged to increase their R & D activity or to explore new areas of R & D.

B-2.3 Study Recommendations and Resulting Actions

The study did not recommend changes to the program itself, but recommended that NSERC

(1) increase participation in the program through better publicity;

(2) assist researchers and firms to establish contact by developing mechanisms to "match" researcher and firm; and

(3) encourage changes in the "reward" system for academics by ensuring that collaboration with industry is viewed positively by peers.

B-3 **Awards**

B-3.1 Award made to Dr. C.A.T. Salama, University of Toronto

A Cooperative Research and Development Grant of $752,730 was awarded in 1985 to Dr. C.A.T. Salama, Department of Engineering, University of Toronto. The two-year grant was in support of a project entitled "Technology for VLSI Integrated Circuits".

Dr. Salama is an established leader in Canadian university microelectronics research. He has been very active in developing and transfering his technology to industry through contracts, strategic grants and PRAI research grants. He is also one of the initial promoters of the concept of national microelectronics facility and is presently Chairman of the Board of Directors of both the Canadian Microelectronics Corporation and the National Microelectronics Facility Committee.

Dr. Salama is investigating specialized processes which are critical to the successful implementation of VLSI circuits. The particular topics of research are: advance isolation technology, radiation damage associated with plasma processing and electrical and switching properties of doped polysilicon films.

Two major pieces of processing equipment will be purchased with grant funds in order to carry out these objectives. The required instrumentation consists of a low pressure chemical vapor deposition system and a plasma etching system.

The work will be done in close collaboration with Linear Technology Inc. (LTI) and Northern Telecom Electronics (NTE). The technology to be developed by Dr. Salama and his group will help LTI maintain its share of the linear bipolar integrated circuit market. The company also expects to expand its product line and anticipates that the new products based on the technology from the University of Toronto will generate $25 million in annual sales in 1990. For its part, NTE will gain a fundamental understanding of the device physics as it relates to fabrication processes and will use the knowledge to determine which processing technology is better suited to the establishment of a two micron capability at the company. The overall contribution to this project made by the collaborating companies amounts to $321,000. The companies will provide specialized materials, the time of engineers, technicians and managers as well as access to facilities and processes.

B-3.2 Award made to Dr. R. Tinawi, École Polytechnique

A Cooperative Research and Development Grant of $2,221,800 was awarded in 1985 to a multidisciplinary team of eight professors headed by Dr. R. Tinawi from École Polytechnique. The three-year grant was in support of a project entitled "Développement d'un système CAO dédié aux aménagements hydrauliques à l'usage des industries".

The project will be directed by Drs. C. Marche, M. Soulié and R. Tinawi. The object of the work is to develop, validate and document a CAD system for the design of dams for hydro projects. The proposed system will use the most recent developments for analysis and design in fields such as hydraulic, geotechnical and structural engineering. A central data base will be constructed and linked to the algorithms selected from the various disciplines involved. Interactive graphics will also be fully developed. The research aspects of the work will focus on the interaction amongst various disciplines in order to improve current analysis and design methods.

The system will be developed in close collaboration with nine Quebec firms including six consulting engineering companies. These firms are already experienced in the various aspects of the design of large hydro dams. The overall contribution to the project made by the collaborating companies amounts to $1,683,000. As part of their contribution, the industrial partners will select an assistant director for the project and pay his salary. Their contribution will also consist of computer time, access to company software and data base as well as the time of company engineers and technical staff.

The final product will reduce the cycle time for optimum design of multidisciplinary project and ensure a greater reliability of complexe hydro dam projects. The design tools will increase the competitiveness of the participating companies on the international market.

B-3.3 Awards made to the University of British Columbia

Three major grants totalling $1.2 million to the University of British Columbia through the Council's University-Industry Program:

A. An Industrial Research Chair in Forest Policy Totalling $350,000 Over Five Years

NSERC will contribute approximately $350,000 over the five years towards the development of a research chair in forest policy at the University of British Columbia in cooperation with a number of companies, associations and labour unions in the field of forestry.

The creation of this research chair in forest policy was in response to a need for a new process of forest policy formulation, one which integrates forest policy research with forestry science, economic modelling, new product development, process engineering, etc., and links the user and the scientist in the process. This need has been recognized by the forest industry and its labour unions, by the Canadian Forestry Service of Environment Canada, and by the forestry schools of Canadian universities, all of whom endorsed the award.

As an NSERC industrial research professor, Mr. F.L.C. Reed will conduct research to identify action required to retain Canada's competitive position in the face of changing markets, wood supply and human resources.

The companies, associations and labour unions which will contribute $370,000 over the next five years towards the creation of the chair are the following:

Abitibi-Price Inc., Boise Cascade, British Columbia Forest Products Ltd., Canadian Papermasters Union (CPU), Cariboo Lumber Manufacturers Association, Consolidated-Bathurst Inc., Crestbrook Forest Industries Ltd., Domtar Inc., Fraser Inc., Great Lakes Forest Products Ltd., International Woodworkers of America (IWA), MacMillan Bloedel Ltd., Northern Interior Lumber Sector (of COFI), Nova Scotia Forest Industries, Weldwood Canada, Weyerhaeuser Canada Ltd.

B. A Cooperative Research and Development Grant of $633,400 Over Three Years for the Establishment of a Lead Flash-Smelting Research Facility in the Department of Metallurgical Engineering

NSERC will contribute $633,400 over three years for the establishment of a flash-smelting research facility in the Department of Metallurgical Engineering at UBC.

New flash smelting processes are currently being developed offshore and are seriously being considered as replacement for the aging sinter strand/blast furnace process currently used in Canadian lead smelters. The basic advantages of flash smelting over current methods are the rapidity and labour saving aspects of the reactions and that the reactions are carried out in a single, sealed reactor confining all fumes and noxious gases to an easily handled gas stream. Although the flash smelting process has been developed on a pilot scale in the USSR and Finland, it has not yet operated on a commercial basis; thus Canadian lead producers could be the pioneers in this area and may have to bear the brunt of the teething problems associated with the installation of a full scale flash smelting system.

Because little experimental and technical data exists on the process of flash smelting, fundamental research in this area is urgently required by the Canadian lead industry.

With the assistance of the NSERC grant, Dr. J.K. Brimacombe, a recognized expert in the field of process metallurgy, and Dr. G.G. Richard, both of UBC's Department of Metallurgical Engineering, will construct a small flash system capable of smelting up to 2 Kg/min of lead concentrates. The flash system will be used to study the effect of concentrate type, feed rate, concentrate/oxygen ratio, and burner design on the smelting of lead concentrates supplied by Canadian lead producers.

This project was also supported by four prominent Canadian companies, Cominco, Noranda, Inco, and Hatch Associates (major consultants to the metallurgical industry). The total contribution of these companies over the three year period amounts to $180,000.

C. A Cooperative Research and Development Grant of $246,490 Over Two Years to Upgrade the Computing Facilities in the Department of Oceanography

NSERC will contribute $246,490 over two years to the upgrading of the current tracking-antenna and satellite receiving facility in the Department of Oceanography at the Unviersity of British Columbia through the development of a computer preprocessor and computer system. The original facility has been funded primarily through NSERC strategic grants with an additional five-year loan of equipment from MacDonald-Dettwiler & Associates Ltd. (MDA). The upgrade will make it possible to record incoming satellite data directly on disk rather than on magnetic tape; in so doing, subsequent processing will be streamlined and problems with tape systems avoided.

The data collected are used by Dr. W.J. Emery of the Department of Oceanography in a variety of projects studying wind and sea surface temperature patterns. In addition, data are made available to scientists at the Institute of Ocean Sciences at Patricia Bay and to fisheries scientists in Vancouver.

Current developments are being coordinated with MacDonald-Dettwiler & Associates Ltd., a leading supplier of digital systems in the field of remote sensing from air and space, of data handling from meteorological satellites, and of airline flight operations. MDA has no resident receiving facility, thus the UBC-Oceanography system serves as a testing and development unit for MDA engineers.

This joint satellite receiving facility, the only one located within a Canadian University, offers a unique training environment for graduate students and other professionals. The training received by UBC graduates should prove valuable to both government agencies and industries interested in satellite data.

The commitment of MacDonald-Dettwiler and Associates Ltd. to the funding of this equipment amounts to $130,500 over two years.

B-3.4 Award made to McMaster University

The Natural Sciences and Engineering Research Council (NSERC) will contribute approximately $500,000 over five years to McMaster University for the development of a senior research chair in microwave antenna research and a junior faculty position in microwave signal processing. Contributions from the co-sponsors of these positions, Andrew Antenna, Spar Aerospace and COM DEV, will total $300,000 over five years.

The senior position is co-sponsored by Andrew Antenna Company Ltd. of Whitby, Ontario, and Spar Aerospace Ltd. of Ste-Anne-de-Bellevue, Québec; the junior position in microwave signal processing is co-sponsored by COM DEV of Cambridge, Ontario.

The objective of these chairs is to develop a high profile research program in microwave systems at McMaster. Expected benefits include both industrial spin-offs and a supply of highly trained engineering graduates for employment by Canadian industry.

The Communications Research Laboratory, a pioneer facility in the field of communications, has established itself as the leading Canadian university centre for research with particular emphasis on signal processing. It is housed in a new 1,000 square metre facility.

SECTION C

Canadian Microelectronics Corporation

C-1 History

The Canadian Microelectronics Corporation (CMC) was founded in 1984 as a non-profit corporation to develop and manage a national network of design and test stations for research into very large-scale integrated (VLSI) circuits. A primary goal of the corporation is to provide, through the loan of sophisticated equipment and software, a suitable environment within Canadian universities for the training of research personnel critical to the expansion of Canada's microelectronics industry. This initiative grew out of a special NSERC grant to Queen's University in 1982 to establish a coordination centre for submission of VLSI circuit designs from several universities to Northern Telecom Ltd. for chip fabrication. Since the inception of the CMC, the number of universities participating in the program has grown to 28 and the number of designs submitted to the CMC Implementation Centre for chip fabrication at the Northern Telecom Ltd. foundry has risen to 119 in the most recent round. Twenty universities and eight industries are members of the corporation.

The CMC is funded almost entirely by block grants from NSERC and has a program budget of $18.8 million dollars over five years. In addition, the total contribution of Northern Telecom Ltd. in support of the program is approximately $700,000 annually. To date, the CMC has placed 31 state-of-the-art design stations and 18 test stations in 24 universities in nine provinces. An estimated 130 professors use this equipment to carry out research and to train students in VLSI technology.

C-2 Circuits Designs Implemented by CMC

Table IV-13 provides a report on the progression of circuit designs implemented by CMC from August 1982 to January 1985.

C-3 Equipment Loaned to Canadian Universities

Table IV-14 indicates the numbers of universities having received design and testing stations over the period extending to February 1985.

TABLE IV-1

Strategic Grant Applications, Awards and Success Rates

All Areas

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Applications						
- Number	622	631	549	578	648	812
- Millions of current $	24,216	32,991	31,978	32,659	41,016	56,496
- Millions of 1984	37,865	46,181	40,107	36,348	43,066	56,496
Awards						
- Number	188	212	203	239	224	250
- Millions of current $	6,538	9,095	10,394	12,356	12,558	14,431
- Millions of 1984 $	10,223	12,727	13,035	13,756	13,188	14,431
Success Rate						
- Numbers	30%	34%	37%	41%	35%	31%
- Dollars requested	27%	28%	32%	38%	31%	26%
Mix of Awards						
- Individual	70	79	60	69	68	73
- Group	82	93	98	109	106	111
- Equipment	36	40	45	61	50	64
- Conference	--	--	--	--	--	2

TABLE IV-2

Strategic Grant Applications, Awards and Success Rates

Energy

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Applications						
- Number	191	216	190	144	153	117
- Thousands of current $	6,947	10,122	10,976	7,741	8,543	8,468
- Thousands of 1984	10,863	14,161	13,763	8,616	8,970	8,468
Awards						
- Number	48	70	73	53	58	33
- Thousands of current $	1,579	3,018	3,643	3,020	2,731	1,958
- Thousands of 1984 $	2,469	4,222	4,568	3,361	2,868	1,958
Success Rate						
- Numbers	25.1%	32.4%	38.4%	36.8%	37.9%	28.2%
- Dollars requested	22.7%	29.8%	33.2%	39.0%	32.0%	23.1%
Mix of Awards						
- Individual	23	28	22	14	23	8
- Group	16	32	34	23	16	14
- Equipment	9	10	17	16	19	11
- Conference	--	--	--	--	--	--

TABLE IV-3

Strategic Grant Applications, Awards and Success Rates

Environmental Toxicology

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Applications						
- Number	122	105	89	81	70	82
- Thousands of current $	4,537	5,079	4,445	4,189	3,475	4,483
- Thousands of 1984	7,094	7,105	5,574	4,663	3,649	4,483
Awards						
- Number	35	36	24	42	23	22
- Thousands of current $	1,203	1,329	1,379	1,589	1,090	1,082
- Thousands of 1984 $	1,881	1,859	1,729	1,769	1,145	1,082
Success Rate						
- Numbers	28.7%	34.3%	27.0%	51.9%	32.9%	26.8%
- Dollars requested	26.5%	26.2%	31.0%	37.9%	31.4%	24.1%
Mix of Awards						
- Individual	11	19	8	19	8	7
- Group	16	14	14	15	11	10
- Equipment	8	3	22	8	4	4
- Conference	--	--	--	--	--	1

TABLE IV-4

Strategic Grant Applications, Awards and Success Rates

Oceans

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Applications						
- Number	59	65	59	56	63	63
- Thousands of current $	2,538	3,522	3,468	3,311	4,430	4,341
- Thousands of 1984	3,969	4,928	4,348	3,685	4,651	4,341
Awards						
- Number	27	29	26	22	22	20
- Thousands of current $	1,046	1,303	1,202	1,435	1,352	1,337
- Thousands of 1984 $	1,636	1,823	1,508	1,597	1,420	1,337
Success Rate						
- Numbers	45.8%	44.6%	44.1%	39.3%	34.9%	31.7%
- Dollars requested	41.2%	37.0%	34.7%	43.3%	30.5%	30.8%
Mix of Awards						
- Individual	6	10	10	7	5	6
- Group	12	10	11	6	12	8
- Equipment	9	9	5	9	5	6
- Conference	--	--	--	--	--	--

TABLE IV-5

Strategic Grant Applications, Awards and Success Rates

Communications and Computers

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Applications						
- Number	86	68	48	59	85	86
- Thousands of current $	3,589	3,364	2,547	4,097	6,524	9,000
- Thousands of 1984	5,612	4,707	3,194	4,560	6,850	9,000
Awards						
- Number	23	31	26	26	24	30
- Thousands of current $	0,966	1,290	1,203	1,732	1,881	2,730
- Thousands of 1984 $	1,511	1,805	1,509	1,928	1,976	2,730
Success Rate						
- Numbers	26.7%	45.6%	54.2%	44.1%	28.2%	34.9%
- Dollars requested	26.9%	38.3%	47.3%	42.3%	28.8%	30.3%
Mix of Awards						
- Individual	8	12	4	3	8	5
- Group	12	12	13	14	12	17
- Equipment	3	7	9	9	4	8
- Conference	--	--	--	--	--	--

TABLE IV-6

Strategic Grant Applications, Awards and Success Rates

Food/Agriculture

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Applications						
- Number	164	117	93	95	92	137
- Thousands of current $	6,605	5,615	5,041	5,348	5,445	8,278
- Thousands of 1984	10,328	7,855	6,321	5,952	5,718	8,278
Awards						
- Number	55	29	33	43	36	51
- Thousands of current $	1,744	1,049	1,430	1,702	1,793	2,243
- Thousands of 1984 $	2,727	1,467	1,793	1,894	1,883	2,243
Success Rate						
- Numbers	33.5%	24.8%	35.5%	45.3%	39.1%	37.2%
- Dollars requested	26.4%	18.7%	28.4%	31.8%	32.9%	27.1%
Mix of Awards						
- Individual	22	8	12	13	10	16
- Group	26	12	14	21	18	21
- Equipment	7	9	7	9	8	13
- Conference	--	--	--	--	--	1

TABLE IV-7

Strategic Grant Applications, Awards and Success Rates

Open

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Applications						
- Number	--	60	70	73	104	93
- Thousands of current $	--	5,289	5,502	4,197	7,420	5,975
- Thousands of 1984	--	7,399	6,900	4,671	7,791	5,975
Awards						
- Number	--	17	21	20	32	30
- Thousands of current $	--	1,106	1,536	1,388	2,127	1,558
- Thousands of 1984 $	--	1,547	1,926	1,544	2,234	1,558
Success Rate						
- Numbers	--	28.3%	30.0%	27.4%	30.8%	32.3%
- Dollars requested	--	20.9%	27.9%	33.1%	28.7%	26.1%
Mix of Awards						
- Individual	--	2	4	6	5	11
- Group	--	13	12	8	21	13
- Equipment	--	2	5	6	6	6
- Conference	--	--	--	--	--	--

TABLE IV-8

Strategic Grant Applications, Awards and Success Rates

Biotechnology

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Applications						
- Number	--	--	--	70	81	88
- Thousands of current $	--	--	--	3,776	5,179	5,428
- Thousands of 1984	--	--	--	4,203	5,437	5,428
Awards						
- Number	--	--	--	33	29	21
- Thousands of current $	--	--	--	1,490	1,581	1,053
- Thousands of 1984 $	--	--	--	1,658	1,660	1,053
Success Rate						
- Numbers	--	--	--	47.1%	35.8%	23.9%
- Dollars requested	--	--	--	39.4%	30.5%	19.4%
Mix of Awards						
- Individual	--	--	--	7	9	5
- Group	--	--	--	22	16	10
- Equipment	--	--	--	4	4	6
- Conference	--	--	--	--	--	--

TABLE IV-9

Strategic Grant Applications, Awards and Success Rates

Industrial Materials and Processes

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Applications						
- Number	--	--	--	--	--	146
- Thousands of current $	--	--	--	--	--	10,523
- Thousands of 1984	--	--	--	--	--	10,523
Awards						
- Number	--	--	--	--	--	43
- Thousands of current $	--	--	--	--	--	2,469
- Thousands of 1984 $	--	--	--	--	--	2,469
Success Rate						
- Numbers	--	--	--	--	--	29.5%
- Dollars requested	--	--	--	--	--	23.5%
Mix of Awards						
- Individual	--	--	--	--	--	15
- Group	--	--	--	--	--	18
- Equipment	--	--	--	--	--	10
- Conference	--	--	--	--	--	--

TABLE IV-10

OPERATING GRANTS OF HOLDERS OF STRATEGIC GRANTS
SUBVENTIONS POUR DÉPENSES COURANTES DES BÉNÉFICIAIRES DE SUBVENTIONS THÉMATIQUES
1984-1985

Grant Selection Committee (GSC)/ Comité de sélection des subventions (CSS)	Holders of Strategic Grants/[1] Bénéficiaires de subventions thématiques[1]	Operating Grants Program/Programme de subventions pour dépenses courantes					
		Awards/Subventions					
		Ind.	Team/ Équipe	No Award/ Pas de subvention	Average Ind. Grant/[2] Subv. ind. moyenne[2]	Average Grant for GSC/ Moyenne du CSS	% Difference/ % de différence
Animal Biology/ Biologie animale	35	33	-	2	25,221	23,987	+ 5.1%
Cell Biology/ Biologie cellulaire	47	44	1	2	38,481	29,084	+ 32.3%
Plant Biology/ Biologie végétale	38	35	-	3	42,462	26,497	+ 60.2%
Chem. and Met. Eng./ Génies chimique et métallurgique	55	55	-	-	31,398	24,161	+ 30.0%
Chemistry/ Chimie	52	51	1	-	45,537	32,909	+ 38.4%
Civil Eng./ Génie civil	21	19	2	-	38,259	21,586	+ 77.2%
Comp. & Info. Sci./ Informatique	18	18	-	-	30,319	18,417	+ 64.6%
Earth Sciences/ Sciences de la Terre	31	31	-	-	30,666	22,172	+ 38.3%
Electrical Eng./ Génie électrique	35	33	1	1	31,981	20,803	+ 53.7%
Psychology/ Psychologie	3	3	-	-	13,176	18,616	- 29.2%
Mechanical Eng./ Génie mécanique	19	17	2	-	26,730	21,671	+ 23.3%
Physics/ Physique	26	23	3	-	43,266	24,940	+ 73.5%
Pure & Applied Math./ Mathématiques pures et appliquées	1	1	-	-	30,867	10,021	+208.0%
Space/Astronomy/ Recherche spatiale et astronomie	3	3	-	-	54,912	23,967	+129.1%
Population Biology/ Étude biologique des populations	27	26	-	1	35,763	23,398	+ 52.8%
Industrial Eng./ Génie industriel	2	2	-	-	33,495	16,279	+105.8%
Interdisciplinary Interdisciplinaire	7	7	-	-	25,471	20,240	+ 25.8%
Total/Total	420	401	10	9	34,000	22,279[3]	+ 53%

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[1] Principal Investigators only./Chercheurs principaux seulement.

[2] Average individual operating grant of holders of strategic grants/Subventions pour dépenses courantes moyenne des bénéficiaires de subventions thématiques.

[3] Average for GSCs listed/Moyenne des CSS indiqués.

TABLE IV-11

Committee Membership

Energy

G. Bélanger	Institut de recherche de l'Hydro-Québec
J.L. Brebner	Physique - Université de Montréal
D.E. Brodie	Science - University of Waterloo
R.M. Butler	Chemical Engineering - University of Calgary
J.R. Harbour	Xerox Research Centre, Mississauga, Ontario
A. Hirose	Physics - University of Saskatchewan
J.P. Huni	Alcan Limitée, Jonquières (Québec)
R.A. Karim	Mechanical Engineering - University of Calgary
C.F. Kropp	Ottawa Hydro
P.B. Lumb	Energy, Mines and Resources, Ottawa, Ontario
J.A.L. Robertson	Atomic Energy of Canada Limited Research Co., Ottawa, Ont.
K.J. Roy	Husky Oil Operations Limited, Calgary, Alberta

Environmental Toxicology

C.B. Breckenridge	Ciba-Geigy Corporation, Summit, New Jersey, U.S.A.
Y.K. Chau	National Water Research Institute, Burlington, Ontario
G. Chevalier	Sciences biologiques - Université du Québec à Montréal
B. Colman	Biology - York University
G.R. Douglas	Environmental Health Centre, Ottawa, Ontario
D.J. Ecobichon	Pharmacology & Therapeutics - McGill University
E.T. Garside	Biology - Dalhousie University
R. Greenhalgh	Agriculture Canada, Ottawa, Ontario
L.E. Lillie	Alberta Environmental Centre, Vegreville, Alberta
C.T. Miller	Environnement Canada, Hull (Québec)
J.-P. Weber	Centre de Toxicologie du Québec, Ste-Foy (Québec)

Oceans

S.A.M. Conover	Hardy Associates/Maritime Testing, Dartmouth, Nova Scotia
D.O. Hodgins	Seaconsult Marine Research Limited, Vancouver, B.C.
J.W. Kamphuis	Civil Engineering - Queen's University
P.R. Kry	Esso Resources Canada Limited, Calgary, Alberta
W.C. Leggett	Biology - McGill University
C.D. Levings	Fisheries and Oceans Canada, West Vancouver. B.C.
J.W. Murray	Consulting Geologist, Vancouver, B.C.
S. Pond	Oceanography - University of British Columbia
R.O. Ramseier	Atmospheric Environment Service, Ottawa, Ontario
P.J. Wangersky	Oceanography - Dalhousie University

Communications and Computers

H.D. Barber	Linear Technology Inc., Burlington, Ontario
M.L. Blostein	INRS - Télécommunications, Verdun (Québec)
G. Bochmann	Informatique et recherche op. - Université de Montréal
P. Cashin	Bell Northern Research, Nepean, Ontario
D.A. George	Engineering Science - Simon Fraser University
B. Hindson	Communications Canada, Ottawa, Ontario
S. Hussain	Microtel Pacific Research Limited, Burnaby, B.C.
M.R. Ito	Electrical Engineering - University of British Columbia
G. Panther	Siltronics Limited, Kanata, Ontario
W. Sawchuk	CRC, Communications Canada, Ottawa, Ontario
L. Shafai	Electrical Engineering - University of Manitoba

Food/Agriculture

M. Boulet	Sciences et technologie des aliments - Université Laval
R.B. Buckland	Animal Science - Macdonald College
J.J. Dufour	Agriculture Canada, Lennoxville (Québec)
L.A. Hunt	Crop Science - University of Guelph
W.R. McGregor	Eli Lilly and Company (Canada) Limited, Edmonton, Alberta
B.A. Oaks	Biology, McMaster University
S. Pawluk	Soil Science - University of Alberta
G.D. Phillips	Animal Science - University of Manitoba
M. Quevillon	Institut Armand Frappier, Laval-des-Rapides (Québec)
W.D. Seabrook	Biology - University of New Brunswick
J.S. Wenzel	J. Wenzel Food Technology Associates Inc., Kingston, Ont.
C.G. Youngs	Private Consultant, Saskatoon, Saskatchewan

Open

A.J. Alcock	National Research Council, Ottawa, Ontario
A. Martel	Laboratoires Bristol, Candiac (Québec)
J.J. McMullen	Datap Systems, Calgary, Alberta
J.N. McNeil	Biologie - Université Laval
D. Mills	Ontario Hydro, Toronto, Ontario
E.R.W. Neale	Academic - Memorial University of Newfoundland
M. St-Jacques	Chimie - Université de Montréal
C.J. Walters	Institute of Animal Resource Ecology - U. British Columbia

Biotechnology

L.A. Babiuk	Veterinary Microbiology - University of Saskatchewan
G. Bellemare	Biochimie - Université Laval
C.T. Bishop	National Research Council, Ottawa, Ontario
D.C. Burke	Allelix Inc., Mississauga, Ontario
C.L. Cooney	Massachusetts Institute of Technology, Cambridge, Mass.,USA
J.D. Friesen	Medical Genetics - University of Toronto
R. Knowles	Microbiology - McGill University
J.P. Kutney	Chemistry - University of British Columbia
M. Moo-Young	Chemical Engineering - University of Waterloo
D. Rouleau	Génie chimique - École Polytechnique
T.A. Thorpe	Biology - University of Calgary
L.C. Vining	Biology - Dalhousie University

Industrial Materials and Processes

M.A. Bergougnou	Chemical/Biochemical Engineering - U. of Western Ontario
S.J. Bonham	Mechanical Engineering - University of New Brunswick
I.G. Dalla Lana	Chemical Engineering - University of Alberta
P.A. Hamill	National Research Council, Ottawa, Ontario
G.E. Hazell	Union Carbide Canada Limited, Brampton, Ontario
A. MacLean	Metallurgy and Materials Science - University of Toronto
T.J. McCann	RTM Engineering Limited, Calgary, Alberta
J.A. Morrison	Institute for Materials Research - McMaster University
S.R. Morrison	Physics - Simon Fraser University
J.L. Valade	Centre de recherches en pâtes et papiers - Université du Québec à Trois-Rivières

TABLE IV-12

UNIVERSITY-INDUSTRY PROGRAM

Fiscal Commitments

as of March 31, 1985

(in thousands of dollars)

ELEMENT	#	NSERC (INDUS) 83-84		#	NSERC (INDUS) 84-85		#	NSERC (INDUS) 85-86		#	NSERC (INDUS) 86-87		#	NSERC (INDUS) 87-88		#	NSERC (INDUS) 88-89		#	NSERC (INDUS) 89-90	
CRD	0	0	(0)	47	4,760	(2,555)	36	3,028	(2,134)	22	1,942	(1,392)	1	143	(30)	0	0	(0)	0	0	(0)
IRC	1	90	(50)	4	416	(249)	5	439	(236)	5	442	(236)	5	292	(213)	4	216	(163)	0	0	(0)
PRAI	18	1,395	(644)	37	2,595	(1,143)	18	1,325	(686)	9	603	(412)	0	0	(0)	0	0	(0)	0	0	(0)
SEF	2	344	(50)	9	1,064	(437)	4	310	(277)	1	163	(60)	0	0	(0)	0	0	(0)	0	0	(0)
SIF	9	73	(0)	18	128	(14)	11	67	(0)	1	13	(0)	0	0	(0)	0	0	(0)	0	0	(0)
W&S	0	0	(0)	10	65	(0)	0	0	(0)	0	0	(0)	0	0	(0)	0	0	(0)	0	0	(0)
TOTAL	30	1,902	(744)	125	9,028	(4,399)	74	5,169	(3,333)	38	3,163	(2,100)	6	435	(243)	4	216	(163)	0	0	(0)

CRD: Cooperative Research & Development
IRC: Industrial Research Chairs
PRAI: Project Research Applicable in Industry
SEF: Shared Equipment & Facilities
SIF: Senior Industrial Fellowship
W&S: Workshops & Seminars

TABLE IV-13

Circuit Designs Implemented by CMC

Date	Number of Universities Participating	Number of Designs Fabricated
August 1982	5	27
December 1982	8	33
April 1983	10	37
September 1983	6	44
January 1984	10	61
May 1984	14	60
September 1984	10	47
January 1985	19	119

TABLE IV-14

Equipment Loaned by the CMC* to Canadian Universities

No. Universities	No. Design/Test Stations Per University
5	1 / 0
1	2 / 0
1	0 / 1
10	1 / 1
7	2 / 1
24	31 / 18

* as of February 1985

APPENDIX V

REPORT OF NSERC'S SUPPORT OF ENGINEERING RESEARCH AND GRADUATE STUDIES

SECTION A - REPORT OF NSERC'S SUPPORT OF ENGINEERING RESEARCH AND GRADUATE STUDIES

A study of NSERC's support of research and graduate studies in engineering was published by the Council in 1983(1).

The principal conclusions and recommendations contained in this study, together with a summary of the actions taken on the various recommendations, are given below.

1. It is recommended that the engineering grant selection committees (GSCs) (other than industrial engineering) be given strong encouragement to lower their competition success rates for operating grants.

   Action: All grant selection committees have been encouraged to be more selective.

2. It is concluded that there is not now a significant problem with respect to the awarding of very small grants by the engineering GSCs.

3. For a variety of reasons the engineering GSCs do not give as large grants to their best researchers, in general, as do most other GSCs.

4. It is concluded that the engineering research document (form 135) has had a beneficial effect but that increased attention to this document by applicants and grant selection committees is desirable. Some reasons for the reluctant use of form 135 are suggested and some ways for encouraging greater use are proposed.

   Action: University research grants officers have been specifically asked to ensure that all applicants for grants in engineering-related areas are provided with a copy of form 135. The Engineering GSCs have held policy meetings and all have discussed the use of the form in evaluating engineering applications.

5. It is concluded that there are now no major problems relating to the use of the special merit supplements by the engineering GSCs and that this scheme has had beneficial effects for the engineering research community.

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(1) R.J. Kavanagh, Report on Support of Research and Graduate Studies in Engineering, NSERC, July 1983.

6. It is recommended that site visit team members be better informed about their responsibilities and that the composition of teams be such that they include experienced GSC members and an NSERC staff member.

   Action: The responsibilities of the members of site visit teams have been discussed at policy meetings of the engineering GSCs, and it has been agreed that all future site visit teams will include one experienced GSC member. NSERC staff will attempt to participate in visits as often as possible, but limited staff resources preclude representation on all visits.

7. It is recommended that increased staff resources be assigned by NSERC to the task of preparing comment letters to applicants and that care be taken to ensure that the contents of such letters be factually based.

   Action: NSERC recognizes that increased staff resources may be required in the future for the task of preparing comment letters. In addition, GSCs have been asked to be more specific in the comments to be sent to applicants, and to ensure that the comments reflect the committee consensus.

8. It is recommended that the engineering GSCs be strongly encouraged to use external referees for all applications in the fields which are not adequately covered by GSC members.

   Action: All engineering GSCs agree; moreover, one (industrial engineering) plans to use external referees for all applications.

9. It is recommended that consideration be given to including persons from the United States as members of the engineering GSCs.

10. It is recommended that the group chairman play a major role in the selection of chairmen for engineering GSCs.

    Action: Implemented.

11. NSERC should not create an agricultural engineering GSC.

    Action: NSERC staff agree with this recommendation.

12. External referees should be used by GSCs to help adjudicate applications from agricultural engineers.

    Action: For the February 1985 competition, NSERC established a full referee system for all applicants in agricultural engineering. An ad hoc committee comprising agricultural engineers from university, industry and government selects external referees and the reports are made available to the appropriate selection committee for use in the evaluation of the proposal.

13. Care should be taken to assign agricultural engineering applications to GSCs having appropriate expertise.

    Action: Implemented.

14. Suitably qualified agricultural engineers should, from time to time, be included as members of the civil and mechanical engineering GSCs and of the food/agriculture panel.

    Action: This has been brought to the attention of the appropriate selection committees.

15. The food/agriculture strategic research area leaflet should explicitly indicate the eligibility of agricultural engineering proposals.

    Action: Implemented.

16. Efforts be made by NSERC staff to ensure that members of agricultural engineering departments are familiar with NSERC programs and encouraged to utilize them.

    Action: Implemented.

17. The applicants to the industrial engineering GSC have changed from being predominantly engineers ten years ago to the present situation where the majority of applications come from non-engineering departments. The number of applications from business or commerce departments is rapidly increasing.

18. The research encompassed by the industrial engineering GSC is, for the most part, not equipment intensive.

19. A number of the projects being funded through the industrial engineering GSC would, perhaps, be more appropriately funded by SSHRC.

    Action: Efforts are continuing to define more clearly the respective mandates of SSHRC and NSERC in the area of industrial engineering. Although there may be a small number of projects funded through NSERC which are closer to SSHRC's jurisdiction, this may be due to NSERC's attempts to ensure that proposals do not "fall between two stools".

20. It is recommended that NSERC staff meet with their SSHRC counterparts to review the funding of research proposals in certain fields with a view to directing applications in these fields to the most appropriate council.

    Action: Implemented.

21. It is recommended that applications in the industrial engineering area be carefully screened by NSERC staff to ensure that inappropriate applications are not sent to the industrial engineering GSC.

    Action: Implemented.

22. It is recommended that particular attention be paid to ensuring that appropriate persons are appointed as members of the industrial engineering GSC.

    Action: Implemented.

23. The strategic grants program has a major impact upon engineering research and substantial funding has been channeled into fields such as electrical engineering and chemical/metallurgical engineering by the program.

24. There is an opportunity for engineering researchers to obtain even greater support via the strategic grants program if more applications are forthcoming.

25. The average operating grant awarded by each of the engineering GSCs is low compared with the average for NSERC, but this measure is not a useful indicator of the adequacy of a GSC's budget.

26. The civil, electrical and mechanical engineering GSCs do not have budgets which are sufficiently large to enable them to match NSERC averages in so far as grants distribution profiles and success rates are concerned.

27. The interim increase in the engineering GSC budgets introduced in 1983-84 reduced, but did not eliminate, the discrepancies between the amounts available per applicant for the civil, electrical and mechanical engineering GSCs and that for NSERC as a whole.

28. It is recommended that the amount available per applicant should be the same for all GSCs unless there is a clear rationale for any variation from the norm.

    Action: The allocations mechanism is under review by the Committee on Allocations.

29. It is recommended that additional action to enhance the support of engineering research should be seriously considered by NSERC.

    Action: This matter is being studied by the Advisory Committee on Allocations.

30. It is suggested that one or more strategic grants areas be established which would present opportunities for increased engineering participation, particularly by civil and mechanical engineers.

    Action: A new area entitled "Industrial materials and processes" has been added.

31. It is suggested that NSERC consider the funding of one or more major centres of excellence located in faculties of engineering, involving industrial participation, and dedicated to research and development in one or more areas of national importance.

    Action: Through its University-Industry program NSERC has cooperated with a number of industrial organizations in sponsoring several research chairs in Faculties of Engineering.

32. It is recommended that an amount be added to all PRAI grants to cover overhead expenses incurred by the universities.

33. It is recommended that NSERC take action to assist universities in providing the necessary operating and maintenance support for major equipment and major installations.

    Action: NSERC is proposing to implement an expanded program of infrastructure funding. In addition, NSERC has taken steps to ensure that requests for infrastructure funding coupled with major equipment and major installation applications are carefully reviewed concurrently.

34. It is recommended that an Advisory Committee on Engineering be created by NSERC.

    Action: Implemented.

35. It is recommended that potential industrial members of GSCs be made aware of what is expected of members at the time they are invited to join GSCs and that managers in industry be encouraged to make appropriate time available to their engineers when they are asked to serve on NSERC committees.

    Action: Implemented.

36. It is suggested that the National Committee of Deans of Engineering and Applied Science should invite NSERC representatives to attend their meetings on a regular basis.

    Action: The Deans have accepted this suggestion.

37. It is recommended that consideration be given to introducing a program of Visiting Industrial Professorships.

    Action: Implemented.

38. It is recommended that consideration be given to the introduction of a program of workshops involving NSERC grantees and industrial representatives.

    Action: Implemented.

39. It is recommended that the period of tenure for Senior Industrial Fellows be more flexible.

    Action: Implemented.

40. It is recommended that there be different arrangements for NSERC support for Senior Industrial Fellows depending upon whether they are on sabbatical leave or on leave of absence without pay.

41. Since 1981-82, the economic situation has prompted a trend whereby many more Canadian students are entering engineering graduate programs and winning NSERC scholarships.

42. It is recommended that, in response to the present interest in graduate studies in engineering on the part of students, and as a means of providing special funding for engineering research, a new supplementary program of graduate student support be introduced by NSERC.

43. It is suggested that this new program be used to respond to special needs occurring in any discipline, engineering being an example of a discipline for which there is a current need.

Natural Sciences and Engineering Research Council of Canada
Conseil de recherches en sciences naturelles et en génie du Canada

RESEARCH IN ENGINEERING AND APPLIED SCIENCES

In its first five-year plan, the Natural Sciences and Engineering Research Council acknowledged that, in the past, support provided by NSERC to engineering research tended to be determined by performance indicators more appropriate to research in the natural sciences. Recognizing the importance of providing support to a broad spectrum of engineering activities which may range from the creation of new knowledge to the application of existing knowledge to problem-solving, Council placed greater emphasis on the relevance of research proposals to engineering technology and practice. One of the objectives of this initiative is to assist universities in improving the relevance of graduate programs in engineering in such a way that a larger number of students will view graduate studies as a useful step towards an interesting and productive engineering career in Canada.

Given the similarity in many areas between engineering research and research in applied sciences, Council has now decided to encourage other selection committees and panels that review applied research proposals to use the indicators of productivity applied in engineering.

The selection criteria for operating grants are the merit of the proposal, the excellence of the applicants and the need for funds, as outlined in the Awards Guide. The novelty, feasibility, practicality and intrinsic value to the field are important factors in the review. Although it is considered important to have refereed publications in research journals, this is not necessarily the single most important indicator of excellence and productivity. The following are some of the other factors that can be considered, when appropriate, in the evaluation of the merit of a proposal and the excellence of a candidate:

- Publications

  Specialized publications, technical reports, and conference presentations remain important considerations, where they are recognized by the community as vehicles for the dissemination of results.

- Documented Industrial Contributions

  Documented industrial contributions are also considered. These are measured by reports which might be either general, or confidential in nature to protect proprietary information. Applicants are asked to give the title, the recipient, the date, a concise description, a summary of the results and an explanation of the significance of the work. Applicants should describe the importance of the industrial contribution in terms of the novelty and innovation of the research contribution, rather than the simple provision of a service, and explain how the work relates to the NSERC request.

  It is recognized that research in engineering and applied sciences may lead to an operational process or innovation rather than a research paper. It is also recognized that in some areas of applied sciences, considerable time must be invested before results are apparent and can be gathered for formal publication. Recognition is given to those contributions which lead to commercially viable products, processes or services.

- Research Interactions

  To stimulate the support of applied research activities, recognition is given to industrial or government contacts for the purpose of technology transfer. These contacts may be in the form of consultantships or research contracts approved by the university, and sabbatical or other leave spent in industry, government or business. These interactions should be listed on the Personal Data Form (100) and described on a supplementary page, if required.

- Patents

  In certain fields, patents are inappropriate. However, when appropriate, they are a useful criterion in addition to publications. Greater emphasis is given to those patents protecting technological products, processes or services. Evidence of use of patents is also important.

- Other Contributions

  Other contributions which lead to commercially viable products, processes or services through the transfer of technology and technological innovation may be considered in the evaluation, such as work incorporated into a recommended practice or a building code requirement. The development of computer software which facilitates technology transfer from university to industry would also be taken into account.

NSERC form 100 (Personal Data) includes a section in which such contributions to engineering technology and practice and to applied sciences should be listed. Applicants should append a letter explaining the importance of these additional personal contributions in order to assist the grant selection committees in understanding their value.

In addition to describing and justifying their research project and budget, applicants are encouraged to explain in their grant application how the proposed work relates to the technology and practice of engineering or a relevant scientific profession. This is particularly important for work oriented towards the problem-solving and technological end of the R&D spectrum. The explanation aids in the assessment of the importance of the work and its utility to users of the results.

The above factors are used in the evaluation of both the applicant and the proposed research program.

NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL
CONSEIL DE RECHERCHES EN SCIENCES NATURELLES ET EN GÉNIE

Advisory Committee on Engineering

Terms of Reference

Within guidelines provided by Council, the Advisory Committee on Engineering:

a) advises Council (or permanent committees and task forces as required) on the effectiveness of existing programs and policies in supporting engineering R & D activities in universities and in meeting national needs for highly qualified manpower in the field of engineering and recommends changes as appropriate;

b) suggests possible new mechanisms and procedures for the support of engineering R & D;

c) makes recommendations to Council (or to the Allocations Task Force as required) on the allocation of funds to various activities relevant to engineering and among various engineering disciplines;

d) fosters improved communication and dialogue between NSERC and the engineering community which it serves;

e) makes recommendations on proposed major new initiatives or installations in the field of engineering;

f) undertakes or initiates such studies as may be appropriate to facilitate the conduct of its affairs; it may appoint ad hoc committees or working groups as may be necessary for the conduct of its affairs.

Comité consultatif sur le génie

Mandat

En respectant les lignes directrices énoncées par le Conseil, le Comité consultatif sur le génie:

a) donne des avis et soumet des recommandations s'il y a lieu au Conseil (ou à ses comités permanents ou groupes de travail selon le cas) sur l'efficacité des programmes et politiques à l'appui des activités universitaires de R et D en génie et sur la façon dont ils satisfont aux besoins nationaux de main-d'oeuvre hautement qualifiée en génie;

b) suggère de nouveaux mécanismes de soutien de la R et D en génie;

c) soumet des recommandations au Conseil (ou au Groupe de travail sur les allocations si nécessaire) sur l'allocation des fonds aux diverses activités touchant le domaine du génie et sur la répartition entre les diverses disciplines.

d) favorise de meilleures communications et un dialogue constant entre le CRSNG et la communauté qu'il dessert;

e) soumet des recommandations sur les propositions de nouvelles activités ou de nouvelles installations de grande envergure;

f) entreprend ou commande les études jugées nécessaires à la conduite de ses affaires et nomme les comités de sélection ou les comités spéciaux jugés nécessaires pour la conduite de ses affaires.

.../2

Principles Governing Membership

Membership: between 10 to 15 members as follows:

- the two engineering group chairmen;
- persons from university faculties of engineering or applied sciences, some with experience at a senior administrative level, some with grant selection committee or panel experience;
- engineers from the industrial sector;
- one engineer from the professional organization sector;
- engineers from relevant federal and provincial government organizations;
- the President and Vice-President of NSERC as ex-officio.

Principes régissant la composition

Composition: de 10 à 15 membres, comme suit:

- les deux présidents de groupe dans le domaine du génie;
- des membres de facultés de génie ou de sciences appliquées, certains possédant de l'expérience, administrative, certains possédant de l'expérience des comités de sélection des subventions ordinaires ou thématiques du CRSNG;
- des ingénieurs du milieu industriel;
- un ingénieur provenant d'une association professionnelle;
- des ingénieurs des organismes gouvernementaux (férédal et provinciaux) appropriés;
- le Président et le Vice-président, comme membres d'office.

Adopted by Council (June 1983)
Adopté par le Conseil (juin 1983)

Members of Advisory Committee on Engineering

Membres du Comité consultatif en génie

Dr. G.W. Heinke, Chairman, Department of Civil Engineering, University of Toronto, Toronto, Ontario, Chairman of Committee/Président du comité.

Dr. P. Bélanger, Chairman, Department of Electrical Engineering, McGill University, Montreal, Quebec.

M^me M. Bouchard, ing., Attachée commerciale (Métallurgie et Transports), Hydro-Québec, Montréal (Québec).

Dr. L.T. Bruton, Professor and Dean, University of Victoria, Victoria, British Columbia.

D^r R. Doré, Directeur, École Polytechnique, Montréal (Québec).

Mr. R.W. Hutchins, President, HUNTEC Ltd., Scarborough, Ontario.

Dr. G.M. Lindberg, Director, National Aeronautical Laboratory, National Research Council, Ottawa, Ontario.

Dr. W.F. Petryschuk, Manager, Suncor Refinery, Sunoco Group, Sarnia, Ontario.

Dr. F.R. Shepherd, Manager, Analysis Department, Bell Northern Research, Ottawa, Ontario.

Dr. E.A. Silver, Professor, University of Calgary, Calgary, Alberta.

Dr. D.E. Wells, Professor, University of New Brunswick, Fredericton, New Brunswick.

D^r Y. Giroux, Vice-recteur adjoint à l'enseignement et à la recherche, Université Laval, Sainte-Foy (Québec), Ex-Officio Member/Membre d'office.

Dr. F. Weinberg, Head, University of British Columbia, Vancouver, British Columbia, Ex-Officio Member/Membre d'office.

Mrs. P. Poirier, Grants Officer, Natural Sciences and Engineering Research Council, Ottawa, Ontario, Project Officer/Responsable du projet.

M^lle M. Briand, Conseil de recherches en sciences naturelles et en génie, Ottawa (Ontario), Secretary/Secrétaire.

APPENDIX VI

REGIONAL BREAKDOWN OF NSERC EXPENDITURES

TABLE VI-I

DISTRIBUTION OF NSERC PROGRAM EXPENDITURES BY UNIVERSITY AND PROVINCE

(Thousands of Constant 1984-85 Dollars)

University	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
British Columbia	15,310	18,264	18,934	20,824	20,903	
Simon Fraser	3,168	3,634	3,796	4,543	4,849	
Victoria	2,046	2,879	3,052	3,166	3,856	
(PR BRITISH COLUMBIA)	20,524	24,777	25,782	28,533	29,609	
Alberta	10,369	12,607	13,980	13,914	14,996	
Calgary	5,089	6,606	7,804	8,359	8,264	
Lethbridge	239	342	397	479	605	
(PR ALBERTA)	15,697	19,555	22,180	22,752	23,865	
Saskatchewan	6,317	7,201	7,297	10,045	11,408	
Regina	647	740	806	527	703	
(PR SASKATCHEWAN)	6,964	7,940	8,103	10,572	12,111	
Manitoba	6,326	8,310	8,604	10,194	9,105	
Brandon	118	129	128	196	117	
Winnipeg	244	248	312	268	245	
(PR MANITOBA)	6,688	8,687	9,044	10,658	9,468	
Brock	671	981	1,045	997	888	
Carleton	3,634	4,537	5,027	5,344	6,145	
Guelph	7,570	9,667	10,648	10,458	10,455	
Lakehead	676	785	765	725	991	
Laurentian	473	475	471	463	527	
McMaster	10,428	12,589	12,670	13,695	13,497	
Ottawa	3,610	4,620	5,024	5,948	6,051	
Queen's	5,726	6,426	8,419	8,988	9,589	NOT YET AVAILABLE
Toronto	20,891	24,185	29,075	29,350	31,505	
Trent	267	425	350	378	678	
Waterloo	9,625	11,494	13,158	14,515	16,715	
Wilfrid Laurier	177	177	204	236	255	
Western Ontario	5,863	7,068	8,125	9,280	9,160	
Windsor	2,383	2,958	2,987	2,871	3,271	
York	3,339	4,412	4,101	4,533	4,109	
(PR ONTARIO)	75,333	90,800	102,068	107,779	113,637	
Bishop's	0	0	55	74	72	
Concordia	2,533	3,439	4,572	4,274	4,248	
Ecole Polytechnique	3,265	4,000	4,793	4,336	5,168	
Laval	5,579	7,292	7,665	9,269	9,978	
McGill	10,571	12,257	14,299	15,098	15,161	
Montreal	7,222	7,783	8,046	8,628	10,596	
Quebec	3,883	4,499	4,742	5,539	5,969	
Sherbrooke	2,417	3,094	4,462	4,107	3,901	
(PR QUEBEC)	35,472	42,364	48,634	51,323	55,093	
Moncton	409	405	424	412	437	
Mount Allison	334	357	513	499	466	
New Brunswick	2,713	3,675	4,127	4,035	4,692	
Saint Thomas	0	0	39	54	50	
(PR NEW BRUNSWICK)	3,456	4,438	5,103	4,999	5,645	
Acadia	374	428	617	475	511	
Dalhousie	4,541	5,478	5,927	6,001	6,812	
Mount Saint Vincent	59	64	85	127	99	
Tech. Univ. of Nova Scotia	591	1,371	1,528	1,475	1,266	
Nova Scotia Agr. College	0	0	0	82	107	
Univ. College of Cape Breton	0	0	0	19	41	
St. Francis Xavier	545	631	634	767	597	
Saint Mary's	243	245	301	307	626	
(PR NOVA SCOTIA)	6,355	8,217	9,094	9,253	10,059	
Prince Edward Island	113	150	137	209	140	
(PR PRINCE EDWARD ISLAND)	113	150	137	209	140	
Memorial	3,939	3,858	4,460	4,374	5,086	
(PR NEWFOUNDLAND)	3,939	3,858	4,460	4,374	5,086	
TOTAL UNIVERSITIES	174,539	210,788	234,605	250,453	264,713	
OTHER IN CANADA	7,235	8,006	8,660	10,946	18,511	
TOTAL IN CANADA	181,774	218,794	243,265	261,399	283,224	
OUTSIDE CANADA	3,361	3,713	3,771	4,276	5,128	
GRAND TOTAL	185,135	222,507	247,036	265,675	288,352	

TABLE VI-II

DISTRIBUTION OF NSERC PROGRAM EXPENDITURES BY PROVINCE AND REGION
(Thousands of Constant 1984-85 Dollars)

Region	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
BRITISH COLUMBIA	20,524	24,777	25,782	28,533	29,609	
Alberta	15,697	19,555	22,180	22,752	23,865	NOT YET AVAILABLE
Saskatchewan	6,964	7,940	8,103	10,572	12,111	
Manitoba	6,688	8,687	9,044	10,658	9,468	
PRAIRIES	29,348	36,183	39,327	43,982	45,444	
ONTARIO	75,333	90,800	102,068	107,779	113,637	
Francophone Quebec	22,357	26,669	29,708	31,878	35,611	
Anglophone Quebec	13,105	15,695	18,926	19,445	19,482	
QUEBEC	35,472	42,364	48,634	51,323	55,093	
New Brunswick	3,456	4,438	5,103	4,999	5,645	
Nova Scotia	6,355	8,217	9,094	9,253	10,059	
Prince Edward Island	113	150	137	209	140	
Newfoundland	3,939	3,858	4,460	4,374	5,086	
ATLANTIC	13,862	16,663	18,794	18,835	20,930	
OTHER IN CANADA	7,235	8,006	8,660	10,946	18,511	
TOTAL IN CANADA	181,774	218,794	243,265	261,399	283,224	
OUTSIDE CANADA	3,361	3,713	3,771	4,276	5,128	
GRAND TOTAL	185,135	222,507	247,036	265,675	288,352	

TABLE VI-III

INDEX OF NSERC PROGRAM EXPENDITURES BY PROVINCE AND REGION
(Constant 1984-85 Dollars, 1979-80 = 100)

Region	Base Year 1979-80	First Five-Year Plan (1) 1980-81	(2) 1981-82	(3) 1982-83	(4) 1983-84	(5) 1984-85
BRITISH COLUMBIA	100	121	126	139	144	
Alberta	100	125	141	145	152	NOT YET AVAILABLE
Saskatchewan	100	114	116	152	174	
Manitoba	100	130	135	159	142	
PRAIRIES	100	123	134	150	155	
ONTARIO	100	121	135	143	151	
Francophone Quebec	100	119	133	143	159	
Anglophone Quebec	100	120	144	148	149	
QUEBEC	100	119	137	145	155	
New Brunswick	100	128	148	145	163	
Nova Scotia	100	129	143	146	158	
Prince Edward Island	100	133	122	186	124	
Newfoundland	100	98	113	111	129	
ATLANTIC	100	120	136	136	151	
OTHER IN CANADA	100	111	120	151	256	
TOTAL IN CANADA	100	120	134	144	156	
OUTSIDE CANADA	100	110	112	127	153	
GRAND TOTAL	100	120	133	144	156	